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The general transport situation in 1921.

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PREFACE.

The *League of Nations* has published two volumes of about 500 pages (1), giving the statements presented by the countries participating in the first General Conference on communications and transit held in March-April 1921 at Barcelona.

This Conference had been called together by the Council of the League of Nations, and was composed of delegates from all the countries, including those which were not members of the League.

The matters upon which statements were asked from the different countries on points covering railways were as follows :

1. *Material.* — The condition of the permanent way and buildings; work to be carried out; matters effecting definite reconstruction; matters of improvement or of creating new lines; condition of rolling stock.

2. *Traffic.* — Train working; movement of passengers; tonnage of goods.

3. *Rates.* — Increase in rates for passengers and for goods.

4. *Fuel.* — Total consumption of various kinds of fuel; provision of fuel; net cost per ton.

5. *General financial position of the railways.*

Inquiry was also made into the actual situation both with regard to sea navigation and canals, also the development of motor and aerial transport.

The following countries have replied to the questionnaire :

Austria,	Esthonia,
Belgium,	Finland,
Bolivia,	France,
Brazil,	Germany,
Bulgaria,	Great Britain,
Canada,	Greece,
Chile,	Guatemala,
China,	Haiti,
Czechoslovakia,	Hungary,
Denmark,	India,

(1) League of Nations : *The general transport situation en 1921*, t. I and II, Geneva, 1922.

Italy,
Japan,
Latvia,
Lithuania,
Luxemburg,
Netherlands and Dutch Indies,
Norway,
Panama,
Paraguay,
Persia,
Poland,
Portugal and Portuguese colonies,
Roumania,
Serb-Croat-Slovene State,
Spain,
Sweden,
Switzerland.

Professor Tajani of the Milan Royal Polytechnic School, had charge of the compilation, as well as of the publication of a condensed summary, in the most convenient form, of the nature of the crisis which faces, after the war, the means of communication and transport.

We reproduce herewith that part of this introduction which refers exclusively to railway communication, and we take this opportunity of thanking most warmly Mr. Tajani, member of the Permanent Commission of our Association, for his great work. J. V.

I. — State of Railway Communications before the War. — Organisation of International Transport.

Before the recent war, Europe, and more especially Central and Western Europe, had enjoyed a long period of peace. This circumstance had given rise to an extensive development of railways — a development which was far more limited in Eastern Europe, as is shown in the following table — and had furthered the adoption of all measures calculated to increase the efficiency of transport. The effect of these measures was to eliminate the obstacles to freedom of trade presented by political and customs frontiers and the multiplicity of railway administration; thus they brought about an increase in the work performed by the railways, while the cost remained unchanged. In this respect it may be said that the railways of continental Europe, and, more especially, those of the central and western States, had arrived at an almost perfect system of internationalism, thanks to certain agreements concluded between the countries concerned, either on technical questions, or on the commercial relations established by the development of the railways.

The chief agreement of a technical nature is that regarding the *technical uniformity of railways* which resulted from successive conferences held at Berne from 1886 onwards, at the invitation of the Swiss Government, to which nearly all the European countries adhered (Switzerland, Germany, France, Austria-Hungary, Italy, Russia, Belgium, Sweden, Norway, Denmark, Bulgaria, the Netherlands, Roumania, Greece, Luxemburg and Serbia). At these conferences the essential dimensions of the track (gauge) and of all parts of the rolling-stock affected by this gauge were determined, together with the formation of trains, each State undertaking to enforce the adoption of these dimensions by law. The agreement was to be perpetual and the regulations were revised from time to time, either to bring them up to date, or to extend them. A final protocol, dated 1911, had effected a marked improvement in the previous regulations by authorising the introduction of an international type (*gabarit passe-partout*) and by approaching the solution of a technical problem, which is extremely important from an international point of view : that of the use of the continuous brake on goods trains.

Thus the almost unlimited exchange of rolling-stock belonging to the various administrations was made possible. It is generally known that the exchange of rolling-stock is a necessary condition for a through service *i.e.*, a service which, despite the existence of different managements, appears to the public to be operated exactly as though under the control of a single managing body.

COUNTRY.	Length of line in operation in 1912, in miles.	Area of country, in square miles.	Population, in millions.	Length of line per 100 square miles.	Length of line per 10 000 inhabitants, in miles.	Length of line operated in 1920, in miles.
1. Germany	38 982	208 811	66.146	18.6	5.9	36 066
2. Austria-Hungary	28 474	261 208	51.018	10.9	5.5	...
Czecho-Slovakia (1)	...	53 670	13.000	15.6	6.2	8 447
Austria	...	...	...	...	...	4 117
Hungary	...	...	...	...	...	4 382
Serb-Croat and Slovene State	...	10 193	12.436	...	...	5 565
3. Great Britain	23 412	121 421	45.472	19.3	5.2	24 397
4. France	31 213	207 113	39.252	15.0	8.0	...
5. Russia, including Finland	38 648	2 081 166	128.171	1.8	2.9	...
Finland	...	...	...	...	...	2 476
Lithuania	1 753	32 820	4.500	...	...	1 939
Esthonia	...	...	...	...	...	616
Latvia	...	28 695	2.950	...	...	1 771
Poland	...	...	...	...	...	9 836
6. Italy	10 825	110 661	34.370	9.7	3.2	12 501
7. Belgium	5 381	11 390	7.386	44.9	7.3	...
8. Luxemburg	326	1 004	246	32.6	13.2	...
9. Netherlands	1 985	12 780	5.825	15.3	3.4	...
10. Switzerland	2 994	15 985	3.559	18.6	8.4	3 321
11. Spain	9 538	191 862	18.618	4.9	5.1	...
12. Portugal	1 854	35 754	5.429	5.1	3.4	...
13. Denmark	2 343	14 865	2.589	15.6	9.1	2 693
14. Norway	1 921	124 445	2.350	1.5	8.2	2 042
15. Sweden	8 868	172 941	5.476	5.2	16.2	9 251
16. Serbia	582	18 649	2.821	3.0	2.1	...
17. Roumania	2 241	50 697	6.860	4.4	3.3	7 257
18. Greece	1 000	24 982	2.632	4.0	3.8	1 859
19. Bulgaria	1 198	37 183	4.253	3.2	2.8	1 584
20. Turkey in Europe	1 047	65 369	6.130	1.6	1.7	...
21. Jersey, Malta and Isle of Man.	68	425	372	16.0	1.9	...
Total for Europe.	214 653	3 893 909	471.761	5.5	4.8	...

(1) The names printed in *italics* denote those countries which were created by the treaties signed at the end of the war.

Only Spain and Russia (partially) did not adhere to the Convention on standard-gauge lines (1 m. 435 [4 ft. 8 1/2 in.]); they kept the broad gauge (1 m. 54 [5 ft. 5/8 in.]) on their main lines. Further, in many countries narrow-gauge railways (1 m. [3 ft. 3 3/8 in.] and less) have been constructed on a large scale. But, if the narrow gauge is justified by the unimportance of the lines using it, a movement in favour of the abolition of the broad gauge is already apparent in the case of the main lines on which it had been adopted.

This principal technical agreement was followed by numerous subsidiary agreements; it may also be added that the friendly diplomatic relations existing between the various countries had rendered the conclusion of agreements concerning international transport an extremely easy matter, and that instances of political and economic rivalry obstructing these schemes of public utility had been of relatively rare occurrence. With regard to passenger services, mention should also be made of the conferences on the subject of time-tables for the purpose of ensuring connections at the frontiers, and of the introduction of international trains made up alternatively, or without discrimination, of rolling-stock belonging to the railways concerned, which traversed several countries and enabled passengers to cover extremely long distances with the greatest speed and convenience, and at the lowest possible cost, without once changing carriages, and without delays for customs examinations — which were carried out in the carriages themselves. When, owing to the small amount of traffic, it was not expedient to form international trains, recourse was had to through carriages covering a previously determined route, which were shunted from one train to the other, thus making it necessary for passengers to change trains. The introduction of combined international tickets, of through tickets of connections, even when a sea-voyage intervened, completed the series of facilities in such a way that the international passenger traffic showed a marked and steady increase.

« Exchange Unions » had been set up for the transport of goods, which allowed the adhering States to use without discrimination rolling-stock corresponding to the uniform type, on condition, naturally, that the regulation concerning compensation for use was observed.

Further, convoyed train-services or series of trains run in connection with each other had been organised, which allowed the direct transport of perishable goods, consigned to distant destinations, without delay at the frontiers.

Together with the agreement for technical uniformity, mention should be made of the commercial agreement known as the « Berne International Convention on the Transport of Goods by Rail », concluded in 1886 at the invitation of Switzerland, and ratified on 14 October 1890, as the result of a diplomatic arrangement between France, Germany, Austria-Hungary, Belgium, Italy, Luxemburg, the Netherlands and Switzerland. Special laws were passed in each of these countries to enforce observance of the Convention, to which Denmark, Bulgaria and Roumania later adhered.

This Convention was in reality a civil and commercial code governing international transportation from territory to territory which was carried out by means of through way-bills, valid for the contracting States; it laid down rules for combined services, the form and legal consequences of the transportation contract, the responsibility of the shippers in case of damage, loss or delay, the exercise of the right of compensation between the railways participating in the transportation, the extinction or prescription of legal proceedings, and jurisdiction in claims. With regard to customs formalities, it was decided that they should be carried out by the railway administration at the frontier concerned, acting as customs officials, on

the basis of the declarations made by the consigner.

Many States had not been content with making the Berne International Convention compulsory. They had also applied its provisions to home transport, with a view to obtaining, in this complicated question, such uniformity of law as would promote the development of trade.

The execution of the Convention was placed in the hands of an international office, which had its seat at Berne and was intended to serve as an information centre, and as an intermediary and arbitrator in cases of litigation between the adhering railway systems and to facilitate financial relations between the various States; one of its special duties was to investigate requests for revision of the Convention, and to arrange for the meeting of further conferences. As a matter of fact, the original text was amended and completed by various instruments : the declaration of 20 September 1893, the agreement of 16 July 1895, the Convention of 16 June 1898, and that of 19 September 1906. The office publishes an official organ every month known as the *Bulletin des transports internationaux par chemins de fer.*

The transport of goods was greatly facilitated by the existence of through services, *i. e.*, of agreements between the various countries for the establishment of tariffs applicable to international transport of specified origin and destination. Merchants might thus easily learn in advance, without making complicated calculations, the total cost of transport, even if it involved many railways in various countries.

Identical principles relating to the application of uniform tariffs, which were in nearly every case modelled on the Berne Convention, had also been applied not only to railways, but to road, river and ocean transport. Thus there were direct services between the railways and the Swiss posts (postes) and betweeen the railways and the Italian and Swiss lakes, the Danube, etc., and between the Continent and England, etc., Germany, Austria-Hungary and Italy in particular had developed the combined railway and waterways service to a remarkable extent by means of agreements concluded between the various railway administrations and shipping concerns. These agreements proved remarkably useful for the development of European exports to the African colonies, Asia Minor and South America.

In view of the services which had unquestionably been rendered by the Convention on the Transport of Goods, an attempt had been made to conclude a similar agreement relating to passengers and luggage. This agreement, while not as important as the above Convention, was none the less calculated to facilitate the relations between the various countries. Switzerland, which is extremely interested in promoting passenger traffic, again took the initial steps in the matter.

A draft Convention, drawn up by the central office, was communicated to the Governments concerned and received their careful consideration. As a result, German, Austrian, Hungarian, Belgian, Danish, French, Italian, Luxemburg, Norwegian, Dutch, Roumanian, Russian, Swedish and Swiss delegates met at a conference at Berne in May 1911. Their discussions led to a final draft convention (30 May 1911) on the transport of passengers and luggage, with through tickets or through luggage checks, not only on railways but, should occasion arise, by other means of transport by road, river or ocean.

The application of this Convention was interrupted by the war.

It need scarcely be added that, prior to these international conventions, railway agreements of all kinds had been concluded between the railway authorities of a single State or of States having a community of interests, of language, etc. In this connection, mention should be made of the Union of the German Railway Administrations (*Ve-*

rein deutscher Eisenbahnverwaltungen) established in 1850, which had unified the technical regulations regarding the construction and operation, the conditions of transport and the general tariff system for nearly all the railways of Germany, Austria-Hungary, Roumania and the Netherlands, *i. e.*, 80 railways forming a system of approximately 62 000 miles. Nevertheless, from an international point of view, this agreement was merely a semi-official understanding, as its rules only constituted a moral obligation on the railway authorities and were independent of any Government intervention.

Although this does not profess to be an exhaustive report on the measures taken to facilitate international railway traffic, it should be remembered that special institutions administered the debit and credit accounts between the various railway managements. Owing to the reciprocal use of the means of communication and the loan of rolling-stock, these accounts were of an extremely complicated nature. This inconvenience was, however, tolerated, in view of the great and mutual advantages in the development of transport. Special joint offices for liquidation and control were set apart for the administration of these accounts, as, for example, the Hanover office for transport relations between Germany and Austria-Hungary, and the Szégédin office for relations between Austria-Hungary and Roumania, that of Munich for transport between Austria-Hungary, Germany and Italy, and that of Strasburg for Franco-German and Italo-German through transport *via* the St. Gothard, etc.

There were organisations similar to the above for liquidating the charges for the use of rolling-stock between countries belonging to the same « Exchange Unions ». Thus the International Exchange Union includes the greater part of the French, Belgian, Dutch, Luxemburg, Swiss, German, Austro-Hungarian and Roumanian railways and the Russian Vienna-Warsaw standard-gauge line; this union, which has its central office at Magdeburg, was responsible for the enforcement of the « Regulations for the use of rolling-stock by railways belonging to the International Union ». « The Union between the railways of central Europe, on the one hand, and of Italy on the other » includes the Swiss, Austrian, Hungarian, German, Belgian, Dutch and Italian railways, and had offices at Strasburg and Magdeburg, where hire rates were liquidated in conformity with the « Regulations for the reciprocal use of rolling-stock, etc. ». Mention should also be made of the « Austro-Oriental Union » for the Austrian, Hungarian, Roumanian, Serbian, Bulgarian and Eastern Turkish railways, with offices at Budapest.

But this does not complete our survey. The prolonged peace had given rise to a belief in the stability of frontiers and had promoted the construction of plant to facilitate railway relations at the junction of the lines of one State with those of another in order that transport should be impeded as little as possible in crossing from one country to the other; thus, huge international stations had been erected which did not always correspond exactly to the frontiers, but which served as virtual customs and railway frontiers. They were furnished with all the equipment necessary for establishing communication between various railway administrations, but their operation was, as a rule, in the hands of a single administration which acted on behalf of the others.

Mention might also be made of railways crossing frontiers, constructed at the cost of several States. The obstacles arising from the complicated nature of the agreements involved were surmounted by the good will of the contracting countries.

Many engineering works bear witness to the effect of peace on the development of lines of communication; for example, the tunnels through the Alps, such as

that of Mont Cenis, the cost of which was borne by Italy and France; the St. Gothard tunnel, for which Germany, Switzerland and Italy contributed, and the Simplon, which was the result of an agreement between Italy and Switzerland.

The International Railway Congress Association, with offices at Brussels, has a membership of 246 railway companies, including those of the United States of America, and embraces a total system of approximately 257 000 miles. Although very general in its aims, this association has contributed, indirectly doubtless, but appreciably, to technical unification. Germany only belonged to this association for the period 1905-1914.

Thus it may be said that before the war the railways had reached a state of development calculated to produce the most excellent results.

As a result of the war, this great system of agreements was swept away, and this largely accounts for the present crisis in international traffic.

The League of Nations has assumed the task of restoring pre-war conditions by means of already existing permanent organisations and general conferences between the States. It intends to improve them, when opportunity offers, by replacing the limited and fragmentary agreements by conventions, which will guarantee the observation of the fundamental provisions of the Covenant in an effective and permanent manner.

A final observation must be added to these general considerations. During the war, State railway operation was extended at the expense of private enterprise. The serious difficulties arising out of the war even led certain companies to give up the lines they held under concessions. Changes of regime hastened repurchase; the lines of conquered countries came into the hands of the new Governments. Apart from these facts, the war led to the concentration of management in the hands of a single directing body. In certain countries before the war the railways were operated by several companies.

We have not exact statistics at our disposal, but it may be asserted that at present there are few countries in Europe where private administration is clearly predominant. The only countries in this position are England, France and Spain. During the war, England and France centralised the railway service of the whole country to ensure unity of direction of all traffic, both military and civil. The satisfactory result of this unity of direction, from a technical point of view, gave rise to a movement in favour of general nationalisation of the railways in both countries, but experience has shown that State management is not conducive to economical working. For this reason, at the end of the war, the railways were restored to the companies and private operation resumed. It is not unlikely that similar considerations of economy will, in the future, induce the new States, which have enormous railway deficits, to adopt the same method when they reorganise their railways on a permanent basis.

II. — General Effects of the War on Communication by Rail.

Tradition has it that war has a beneficial effect on means of communication.

The wars which led to the formation of the Roman Empire gave a considerable impetus to the construction of ordinary roads; shipping developed at the time of the Crusades; the incessant wars of the Napoleonic age were well calculated to promote the extension of communications; lastly, the wars waged in the course of the twentieth century furthered the extension and development of railways.

As regards the world war of 1914-1918, favourable effects of the progress of motor traction and aerial transport may also be noted; but, as far as can be seen at present, its effects were distinctly prejudicial to the railways.

This by no means contradicts the lessons of the past, which have just been mentioned. It is true that means of communication in their early stages of development can be improved by wars, of which they are an essential element; on the other hand, in the case of an organisation which is already highly developed and efficient, the ruthless necessities of military operations can only have a harmful effect, due especially to their disorganising elements.

It is quite possible that a few lengths of railway line were built here and there for exclusively military purposes, but this unimportant increase made no difference in the general state of development at which the railway systems had arrived in 1914. This development represented the sum of intensive building activities which had lasted, without interruption, for over three-quarters of a century. The military railways built in France by the Americans, those laid on the Russian frontiers by the Germans, and the connecting lines built by Italy on the Austrian frontier, together, make up a number of kilometres which would have seemed remarkable in the early stages of railway construction; today they amount to a very small fraction of the lines laid in time of peace.

Thus, the useful effects are negligible; the damage is very different in extent.

We already pointed out one of the regrettable consequences of the war when we noted the destruction of international organisations for increasing the efficiency of transport services by rendering them more rapid, certain and economical, and by freeing them from the obstacles raised by the existence of frontiers. These organisations will have to be entirely re-constituted. To this extremely serious harm must be added damage of a material nature. The chief item under this heading is the demolition carried out in the invaded areas.

The destruction of means of communication is a regrettable necessity in military operations and retreats; but in the last war the extremely efficient technical preparations of certain of the belligerents enabled them to carry on a systematic work of destruction; thus, the work of reconstruction has been rendered difficult, long, and costly. High explosives were used to tear up and destroy track; all buildings and plant were razed to the ground; not only were the arches and floors of bridges destroyed, but their piers and abutments were levelled to the very foundations; even the permanent way was broken up; locomotives and carriages were destroyed or carried off as booty. In those areas which were first invaded and then abandoned, it has been necessary to relay the lines completely; as a rule this situation has been met by means of temporary works carried out with remarkable speed, and the final reconstruction, which will cover a fairly long period, has been postponed. In the meantime, railways in these areas will only be able to run limited services; trains will have to be reduced in number and weight, and continue running at comparatively slow speeds.

To the systematic destruction carried out in the course of retreats — which was of an extremely serious nature — must be added the damage resulting from military operations strictly so-called. Artillery often selected as its objective railway junctions, large stations, bridges, and the openings of tunnels, in order to impede the movement of the enemy; not only the occupied areas, but the areas adjacent to those where military operations were being carried on, suffered this damage, which was, however, far less than that caused by systematic destruction.

The damage caused by the war assumes extreme proportions in France, Belgium, Serbia, Hungary, Italy, Poland and the Baltic States, at any rate in areas which formed the theatre of military operations.

This direct material damage, although enormous, cannot be compared in

gravity with the indirect damage, if the general effects of the war on the means of communication can be so called. Railways are a military instrument of prime importance. In the last war particularly, they were extended up to the very field of battle, and their usefulness was apparent in the whole of the vast sphere of strategy and tactics. They brought all that was necessary for hostilities right up to the front : men, munitions and supplies. They carried back to the rear men who were wounded, or who were taking their turn in rest billets, or proceeding on leave. In the rear they were necessary for supplying material to industries which were producing munitions of war; they sustained the economic life of the country, and assured its food supplies. It was inevitable that in keeping up this gigantic and unceasing effort for so many years, the railways should deteriorate through the excessive overtaxing of all their resources, and especially of their rolling-stock, the present shortage of which is one of the best-known and most striking features of the critical post-war situation.

The wear and tear of railway-stock must be attributed not so much to the intense use of it during the war (on certain systems the information available shows that war traffic exceeded peace traffic by 50 to 100 %) as to the inability to carry out repairs. As the rolling-stock had been concentrated in the zone of operations, it was far distant from its usual place of assembly, where the workshops were situated. The latter, moreover, had been deprived of their oldest and most experienced workmen, who had been called to the colours; they could not, therefore, carry out their normal work at a time when they should have been prepared to cope with an entirely exceptional situation.

Special mention should be made of the fact that, owing to the shortage of coal, engines were run on all sorts of fuel of inferior quality, and, as necessity arose, given to untrained drivers who had not completed the requisite period of apprenticeship.

Although the effects of the war are most evident in rolling-stock, it is none the less true that the equipment and plant also suffered from the abnormal conditions created by the war, if only in the matter of upkeep. The statements show clearly that, on certain lines, the speed of trains had to be reduced, because it was impossible to replace worn-out wooden sleepers. Further, in normal times, railway equipment is constantly being improved and augmented, and so enabled to meet the varying and growing requirements of transport; as may be readily imagined, such improvements and additions were completely neglected during the war.

Without dwelling on this aspect of war damage, which it is easy to appreciate, we shall mention other causes of deterioration of a less obvious nature. Further, we shall have occasion to note that, while strictly material damages, such as the decrease in engines and carriages, the lack of repairs to plant, and others of a similar nature, may be made good at a more or less considerable financial sacrifice, this does not apply to the change in the direction of the currents of traffic, which is intimately connected with the political consequences of the war.

By altering the frontiers, the formation of new States gave rise to new situations even as regards the railways. The great changes in frontiers have rendered international stations (frontier stations) useless, and have made it necessary to build new ones.

Now, as we have already had occasion to point out, international stations are complicated organisations, which generally require a long period of years for their complete development, for they must be provided not only with purely railway equipment, but also with accommodation for customs, for health inspection, for postal services and police, and

must be subject to appropriate regulations. Thus, the abandonment of already existing international stations and the building of new ones forms a very heavy item of expenditure. In addition to this, the choice of the site of frontier stations requires lengthy negotiations between the countries concerned. A point actually situated on the frontier is seldom suitable for the erection of large buildings (the case of the Brenner Station, a small Alpine refuge on the new frontier between Austria and Italy, is a typical example). Thus a site has to be selected which is on one or other of the two territories, the political rivalries and complications which are inevitably brought into play in such a choice must be smoothed away, and complicated agreements for the mutual operation of the station, not only as regards railway administration but also in the matter of customs, postal service and police supervision, must be concluded. This involves considerable expenditure, which has to be divided between the countries concerned (and this division is in itself a difficulty) at the cost of much time and labour. Meantime all operations on the frontier are held up and international traffic seriously obstructed.

The number of international stations to be transferred is large. It will be sufficient if we mention that for Austria alone new agreements will have to be made for at least 15 stations of this type; Hungary, which formerly required 14 international stations equipped with all the requisite buildings for its traffic, now has to employ 46, which lack the necessary plant, and the majority of which are not suited for the work imposed on them. Czecho-Slovakia requires 30 new international stations for its traffic with Austria and Hungary. It is, however, not necessary to add these figures together, as each State considers that the joint stations should belong to it; but in any case there is extremely urgent work to be carried out, and no funds to do it with.

The greater railways had followed routes which corresponded to the economic policy of the countries they traversed rather than to local topographical and geographical conditions. Technical progress and the possibility of drawing on unlimited financial resources made it unnecessary to restrict the choice of routes. Thus it became a simple matter to transform these lines into a political instrument of prime importance by creating distinct currents of transport, even if this operation revealed the influence of considerations alien to natural economic conditions. The destruction of certain political organisations and the creation of others inevitably diverted the currents of traffic from their original channels. Thus the existing railways were likely to find themselves in the position of rivers suddenly deprived of the streams which feed them, while great masses of travellers and merchandise blocked lines which were not prepared to carry them. The most characteristic manifestation of this phenomenon was in the part of Central Europe which had long been under the domination of the Austro-Hungarian Empire.

Austria's railway policy, as also that of Hungary, had a two-fold object : it attempted to consolidate the economic unity of the political aggregate by establishing commercial solidarity where national solidarity was lacking, and it aimed at keeping in a State of subjection countries which found the imperial yoke irksome and would easily have thrown it off had they been economically developed.

The criticism levelled at the Austrian railway system is that it gave almost exclusive preference to lines running from north to south, which fell in with the plan to foster relations between the regions of Bohemia, Moravia, Silesia and Galicia, rich in mining and agricultural products, with the almost completely

non-productive Alpine districts. This arrangement did not allow all the districts of the empire to participate equally in national and international traffic.

Moreover, it should be pointed out that all the lines converged on the two capitals, so that traffic from the north through German ports, and from the south *via* Trieste, the sole maritime outlet of the Monarchy, always moved towards Vienna and Budapest, more especially Vienna, which had become one of the most notable centres of European commerce. But although this state of affairs might profit Vienna and Austria proper, it did harm to the other regions which, despite their long political connection, had preserved autonomous tendencies which were based on their very ethnic character and for that reason ineradicable.

Through communications from east to west were rare; it is true that this is the direction of the great Danube waterway, but the requirements of modern transport are such that they can only be partially met by the use of waterways. Further, this means of communication did not exist in the northern countries of the Empire. It may thus be said that no attention was paid to the movement of transport from the countries of Western Europe to Russia or the Balkans.

The chief Austrian railways, although admirably planned to meet the requirements of an economic territory which had been created artificially and maintained by railway or customs facilities, have now lost their value by being cut up and incorporated in States with divergent aims.

Of the two main arteries running north, the Trieste-Vienna-Oderburg line includes an Italian section, a Serb-Croat-Slovene section, an Austrian section, a Czecho-Slovak section and a Polish section; and the Verona-Ala-Kufstein line is divided into two sections of different nationality, with an altered frontier passing through a most unsuitable region, as was mentioned above. This also applies to the Marbourg-Franzenfeste line, used for transport between Hungary and the Balkans on the one hand and Southern Austria and Switzerland on the other, and now divided between three countries.

But as we have stated above, while Austria had devoted all her attention to lines running south or north from Vienna, the new States, which lie chiefly from east to west, prefer lines running in that direction. It remains to be seen if and to what extent these tendencies correspond with natural conditions, which are really favourable to lines running from north to south, as these connect countries which differ in climate and production; but there can be no doubt that, pending new organisation, the overthrow of the former organisation has increased the difficulties of trade. It is clear that it will require the consistent effort of many years to adapt the European railway system to the new political formations, especially as the work of reconstruction will of necessity be extremely slow. It is true that the newly formed States have many plans for building new railways to meet the requirements of the national policy adopted by each of these States, but the lack of financial resources, the scarcity of labour and the extremely high prices of all building materials will prevent the speedy realisation of these plans. We must, therefore, count on the effect of measures taken to utilise existing lines and plant in spite of difficulties, rather than on solutions which involve the complete construction of costly lines.

This disorganisation of transport is an extremely serious matter, and it is further aggravated by the exchange situation. If the differences in the exchanges are disastrous their fluctuations are even more so. The fluctuations deprive the railway tariffs of that stability which was their main advantage and which enabled the cost of transport to be previously calculated almost to a farthing, without fear of

surprises. Such calculation is at present impossible. Whereas the pre-war organisation had almost entirely done away with middlemen and forwarding agents, these have now reappeared in great numbers; they increase the transport charges by the cost of their services.

The abnormal condition of the exchanges also renders co-operation between the railway administrations of the various States a matter of difficulty. They can lay down no single rate, for serious differences in values are likely to occur. As no solution of the problem of the exchanges has yet been discovered, it is reasonable to think that, in this connection also, there will for a long time be great difficulty in restoring pre-war conditions in international relations.

We have thus, in our rapid review, brought out the main features of the results of the war on routes and transport. We shall now dwell on the various matters referred to in the questionnaire, and we propose to ascertain the more important general conclusions which may be drawn from the replies of the various States.

III. — Development and Situation of existing Lines. — Improvements and Extensions. — New Lines in Contemplation.

All countries, although confronted by serious difficulties of every kind, have made vigorous efforts to repair their lines. They have pushed on the repair work, which was neglected during the war, and have relaid the lines destroyed in the invaded districts. The reports show that this work of restoration has made remarkable progress. It may now be stated that all the lines existing before the war, together with the lines laid during the war, are once more open for traffic, subject to minor restrictions.

Naturally the situation differs in different countries. In Western Europe the reconstruction of the lines has made rapid progress, for the greater industrial development of these countries has provided them with ample resources. Moreover, the organisation of the States in this part of Europe underwent no important modification. The previous system of railway administration, which remained intact, was able, with comparative ease, to deal with the serious task now imposed upon it. Among the countries of Central Europe, only Italy and Czecho-Slovakia had to repair direct damage; they are proceeding rapidly with this work under the same favourable conditions as prevail in the western countries. But the work of reconstruction is making slower progress in the countries of Eastern Europe, where the creation of new States destroyed a previous railway organisation which was still far from being perfect.

During the period immediately preceding the war the increase in the extent of the European railways amounted to a yearly average of about 1 to 2 %, but the increase varied considerably in different countries. Certain regions could be regarded as saturated with means of communication. This was the case, for example, with a great part of Western and Central Europe. Other regions, again, such as the Balkan countries (Serbia, Roumania, and in particular Bulgaria), were in the full ardour of their first railway development. It was natural that the war should put a stop to all construction for lines of a purely military character.

However, during the war, especially in countries which remained neutral, some lines which had already been begun were opened for traffic.

This was the case in Switzerland with the Frutigen-Brigue line (37 miles), the Jura line, between Moutier and Longeau (8 miles), the Sissach-Olten line (10.5 miles), the Brigue-Gletsch section (29 miles) of the Furka railway, the eastern section of which (Gletsch-Disentis), extending to the Rhone valley, has had to be postponed. All these lines are of international importance. At the time the Swiss statement was drawn up

the second Simplon tunnel (12.4 miles) was being constructed. It has just been completed as we write. The Locarno-Camedo-Domodossola connection, a further link between the Swiss and Italian railways, is also under construction.

During the war Spain also extended her railway system. Several lines (Irun-Madrid, Barcelona-Gerona, Valencia-Jatiba) have been double-tracked. The Canfranc and Puigcerda lines are nearly completed. Plans for a line from Caminreal to Carinena have been approved; this line will enable direct relations to be established from south to north between Valencia and France, *via* Canfranc; the same is true of the projected line from Zamora to Orense, which is intended to give a speedier service between Madrid and Vigo.

The through Madrid-Valencia line has reached the stage of an approved scheme. The Noguera-Mallaresa and Ferrol-Gijon lines, which complete the line along the Cantabrian coast, are under construction. The international line crossing the whole of Spain from Alduides (Pyrenees) to Algeciras, *via* Madrid, is under consideration.

Sweden, Norway, Denmark and the Netherlands also took no part in the war. They call for no special remark. The same may be said of Luxemburg.

In Sweden, a country well supplied with railways in proportion to the population, the lines were maintained in good condition during the war, and a beginning was made with the laying of certain new lines (Ostersund-Gallevare, Forsmo-Hoting, Hallnas-Stensele, and the Sveg-Brunflo line, which is specially important, as it is to ensure communication between Western and Northern Sweden).

In Norway a line from Storen, on the Christiania-Trondhjem line to Dombaas, constituting a through route between Christiania and Trondhjem, *via* Hamar-Dombaas-Storen, will shortly be opened for traffic. Other narrow-gauge lines have been converted to standard gauge.

If we now turn to countries belonging to the Western European group which took part in the war, we observe that the English report makes no special reference to the condition of existing lines and plans for the laying of new lines. This circumstance is quite natural, for the United Kingdom was not the theatre of land operations, and in this connection everything proceeded in that country as in time of peace. The railways, moreover, are so highly developed there that no need for any considerable extension is felt.

The French report supplies us with no information as to the extent to which the railways were destroyed during the German occupation. We gather, however, from Parliamentary papers (Report of the Minister Claveille, dated 13 March 1919, to the President of the Republic) that the actual length of track destroyed or damaged was 3 480 miles out of a total of 33 550 miles of line. 1 510 bridges, 12 tunnels, 590 buildings and 500 water-tanks were destroyed or damaged. The construction and repair workshops at Hellemes, near Lille, were stripped of their machinery and equipment. The workshops at Tergnier, Lens, Amiens, Epernay, Roy and Mohon were rendered unserviceable, permanently or for a long period. All locomotive depôts in the zone occupied by the enemy were completely or partially destroyed, but the work of reconstruction has been pushed on with great rapidity. According to another report of M. Claveille, on 1st July 1919, only a few kilometres of line had still to be completed. 1 025 miles of new line, 1 002 of which are standard gauge, were laid in France during the war, in addition to the work done on stations and engineering constructions.

As we have already pointed out, ambitious programmes for new construction have been considered in many countries, particularly in States recently created, or which have increased their territories as a result of the war.

France is putting forward proposals

for new construction on a large scale. In that country the lines are divided into four classes : railways under construction, which are certain to be completed at an early date (974 miles); railways for which concessions have been granted to companies or which have been declared public utilities, but on which work has not yet begun (372 miles); lines for which concessions have been granted to companies but which have not yet been declared public utilities (431 miles); projected lines favourably considered by the authorities. To form an idea of the extent of this programme, it is important to remember that its completion will involve a total expenditure of about 7 milliards of francs — an expenditure which, according to the estimates, will require to be spread over fifteen years, representing an amount of 450 millions yearly.

Among the most important lines in contemplation, we may mention the two lines crossing the Vosges from Saint-Maurice to Weserling, and from Saint-Dié to Saeles, which are intended to link up Epinal with Mulhausen and Strasburg; the Lérouville-Thiancourt line, which will place Metz in direct communication with Bar-le-Duc; and the Pont-Saint-Vincent-Blainville line, which will connect Toul to Blainville without the roundabout journey *via* Frouard and Nancy. All these lines are intended to improve communications with Alsace, which has been restored to the mother-country.

Moreover, in view of the special importance of the Bordeaux-Odessa route, along the 45th parallel, which is intended to ensure communication, without crossing the territories of Germany and Austria, between the Atlantic, France, Italy, the Serb-Croat-Slovene State and Roumania, with branch lines to Athens and Constantinople, a scheme has been set on foot for a Limoges-Saint-Germain-les-Fossés line to improve the service between Bordeaux and Lyons, and a Saint-Germain-les-Fossés-Paray-le-Monial line, which will provide better communication between Bordeaux and Mulhausen.

Mention may also be made of the line from Rouen to Havre, another crossing the Seine, intended to link up Havre with the west, and the line from Nantes to Paimbœuf.

The Channel Tunnel must be included among important engineering works under consideration.

During the war, 684 miles of railway were completely destroyed, and 249 miles partially destroyed, in Belgium, not to mention 1 400 large and small engineering works, which must be rebuilt. The work of reconstruction was rapidly carried out, and on 1st July 1920, the service was again in full working order, although, in addition to the relaying of the permanent way, it had been necessary to reopen 593 stations and halts which had not been used during the war, to make alterations in the main depôts, to remove 30 000 trucks loaded with ammunition, war material and booty which had been placed on the track for the purpose of impeding the resumption of the service, and to provide for the organisation of a temporary signalling system and the supply of plant for the workshops.

A few new lines were laid while this work was going on, and other lines were double-tracked.

The work which it is proposed to carry out includes the double-tracking of certain lines, while others are to be quadrupled.

In Central Europe, the railway system of Germany, as a result of territorial losses, has been reduced by 4 257 miles. Of this total 1 262 miles are represented by the Alsace-Lorraine system, and the remainder by lines ceded to various States (Memel territory 85 miles, Czecho-Slovakia 19 miles, Belgium 95 miles, Denmark 154 miles, Poland 2 550 miles, Free City of Danzig 91 miles — 2 994 miles in all). No new undertakings are in contemplation. During the war, 760 miles of line were laid.

Owing to territorial losses, Austria at present owns only 4 117 miles of line. Only a few lines were directly affected by military operations, but the whole system is in a bad state of repair. Everything necessary has, however, been done to render the lines capable of meeting the requirements of traffic, though the work of repair was difficult owing to the fact that practically all the lines are mountain railways. Such repairs as were not absolutely essential for safety and all work for the purpose of increasing the capacity of the lines have naturally been postponed. It will be necessary to undertake a great deal of new work such as the building of frontier stations and the adaptation of the system to the new routes which traffic will take; but so far no definite schemes have been prepared. The new constructions under consideration have had to be postponed, and in view of the unsatisfactory position of Austrian finances it is impossible to say when they will be resumed.

Hungary, which, before the war, had a railway system of 12 179 miles, possesses at present only 4 382 miles of line as a result of the loss of part of her territory.

The work necessary to maintain the lines in good condition is in arrears, and in view of internal political difficulties it has not been possible to draw up a programme of new construction.

Czecho-Slovakia is one of the new States where the previously existing railways completely fail to meet the requirements of traffic. This country, which consists of Bohemia, Moravia, and Silesia in the west, and of Slovakia and Sub-Carpathian Russia in the east, is in the form of a trapezium elongated towards the east and west, and is provided with lines running from north to south, whereas it is of the utmost importance that it should own lines running from west to east, parallel to the longitudinal axis of the republic.

As regards international communication, Czecho-Slovakia would, for the reason previously mentioned, favour the opening of the Bordeaux-Paris-Prague-Warsaw and Prague-Bucharest-Black Sea routes.

In this country, as is the case in other new States which have been formed out of territories of previously existing States, a certain lack of uniformity in technical matters relating to railways may still be observed. For example, there are still main lines with heavy rails which are consequently suitable for heavy rolling-stock and express trains, and other lines on which only rolling-stock of limited weight can be run and where it is necessary to reduce speed.

Czecho-Slovakia suffered seriously from the Bolshevik-Magyar invasion in the south-east of Slovakia, but, as has been pointed out, the damage was promptly repaired.

The National Assembly has already adopted a programme for reconstruction work and improvements on the railway system, the completion of which will cost 6 1/2 milliards of crowns. The plan is to construct 15 new lines of a total length of 347 miles and to double-track numerous existing lines.

The result of this scheme would be to open direct communications between the west and the east of the Republic by means of a new line passing through the centre of Slovakia, and it would adapt the system to the new routes and new economic requirements of the country.

In Italy the exigencies of the war led to the expenditure of much labour on existing lines and stations. Moreover, during the war the Montebelluna-Susegana line and the branch from that line to the Castelfranco-Montebelluna line were built. In addition, 93 miles of double track were laid. Signalling appliances were improved and increased.

The Italian railway system has had an addition of 638 miles representing the lines in the Trentino and Julian-Venetia.

The damage done during the invasion has been completely made good.

The scheme for new lines includes the laying of about 500 miles of standard gauge, not to mention the numerous narrow-gauge railways now under construction in the south of the peninsula and in Sicily.

If we turn to Eastern Europe, we cannot fail to be impressed by the exceptional gravity of the railway situation in Poland. Throughout the whole territory of former Russian Poland the length of rail, in proportion to the area of the country, was far below what was necessary to meet the most elementary economic requirements. During the war the entire system was several times destroyed. The same remarks apply to former Austrian Poland; there also the railways, already inadequate, were damaged during the war. The Bolshevik invasions completed the work of destruction.

A typical case is that of the Warsaw-Grodno-Vilna line, one of the principal lines in the country. As it was impossible to repair the viaduct over the Niemen valley near Grodno, which had been twice destroyed, this line was not used for a long time.

Further, the Polish system suffers from a radical defect in that the Russian Government, on strategical grounds, always opposed the linking-up of its system with the German and Austrian systems; with only a few exceptions the lines of former Russian Poland stop short at points ten or more kilometres from the old frontier. Connecting lines have therefore to be laid, and, further, some 435 miles of the broader Russian gauge must be converted to standard gauge to make possible the interchange of rolling-stock with the railways of the rest of Europe.

The railways in Roumania were seriously damaged by aeroplane and Zeppelin bombardments. Moreover, when the national and the Russian armies retired, many railway engineering works were destroyed at the request of the Allied Powers. Further havoc was wrought during the invasions and during the occupation, which lasted more than two years. On his retreat the enemy completed the work of ruin by utterly destroying not only engineering works and buildings but even stock of every description, furniture, archives, etc. Arrangements have been made to reconstruct the system provisionally, for considerable time and an outlay estimated at three or four milliard gold lei at least will be required for its final reconstruction.

Roumania, by annexing Bessarabia, Bukovina and Transylvania, now owns the railways in these territories, but large portions of these railways, and especially of those in Bessarabia and Bukovina, were destroyed during hostilities, and are in need of extensive repairs.

Roumania in her report makes no mention of any plans for new construction.

The railways of Bulgaria, which was continuously at war for many years, with a single respite in 1912, are in bad condition, and it is as much as she can do to maintain a service of trains running at reduced speed (18.6 miles per hour).

It is still too soon to think of laying new lines, apart from a few narrow-gauge lines of purely local interest, and the Mzdra-Vidin standard-gauge line, which is already in operation as far as the Alexandrovo bridge, and of which a section, 18.6 miles in length, has still to be laid to Vidin, the work having been interrupted by the war.

At the close of the great war, Greece owned 714 miles of standard-gauge lines and 774 miles of narrow gauge lines. By the occupation of Thrace and the signature of the Treaty of Sèvres, 371 miles of standard-gauge track passed into the hands of the Greeks. The standard-gauge system has thus a length of 1 085 miles, and the total length of line amounts to 1 859 miles, 820 of which are standard-gauge and 538 narrow-

gauge. 72 % of the total is operated by the State.

The Greek programme for new construction is on a fairly large scale and includes a Drama-Cavalla line in Macedonia (21 miles), a Salonica-Angistra line, also in Macedonia (83 miles), a Klabaka-Janina line (65 miles), a line from the Piræus to Janina and Valina (243 miles), and from Acheloos to Janina (141 miles), all standard-gauge lines, and, in addition, a number of narrow-gauge lines.

The Kingdom of the Serbs, Croats and Slovenes is described in its report as essentially a country for through traffic. Some of the great highways of international trade, both between the north and south and the east and west, will doubtless pass through its territory. There is a marked contrast between these aspirations and the actual inadequacy of the railways, which is to be ascribed, as has already been shown, to the fact that the Austro-Hungarian Empire aimed at making all railway lines run to Vienna and Budapest and at keeping the Serb, Croat and Slovene territories under its sway, without means of communication.

Austria's efforts were specially directed to keeping Serbia in a state of complete political isolation, and the latter, owing to her lack of capital and the special difficulties which the nature of the country places in the way of making new roads, was unable to escape from this isolation by her unaided resources.

The first railway in Serbia — that from Belgrade to Nish, about 155 miles in length — was opened for traffic in 1884, and this line, with an extension to Salonica and a branch to Constantinople, is the main artery of the country.

In the Serb-Croat-Slovene Kingdom there are 5 565 miles of lines but as these lines are not linked up with each other, it may be said that, though the new State is not without railways, it has not as yet any railway system strictly so-called.

The Belgrade-Nish-Salonica railway, which follows the Valley of Morava and then that of the Vardar and is not crossed by any line which might relieve it of part of its traffic, assumed exceptional strategical importance. For this reason it was used during the Austro-Hungarian, German and Bulgarian invasions and at the time of the final retreat it was systematically destroyed. A great deal of time will be required to reconstruct this line; in the meantime it has been temporarily restored sufficiently to enable a train service at reduced speed (15.5 miles per hour).

The new undertakings which it is proposed to carry out, in addition to the complete reconstruction of the lines which were destroyed, must therefore aim at creating a real railway system in the Serb-Croat-Slovene Kingdom which will meet the actual needs of the country and serve to connect it with its allies. The railways which, according to the report, must be reconstructed to achieve this object are :

1° The « Adriatic line », from San Giovanni di Medina to Scutari, Nish, Prahovo and thence to Bukarest and Odessa, an earlier scheme, the most important section of which — that from Nish to Prahovo — had been completed as early as 1914;

2° The lines forming part of the Atlantic-Black Sea route along the right bank of the Danube from Belgrade to Pozarevatz-Brza-Palanka (Serb-Bulgarian frontier), crossing the Danube at the latter station to connect with the Cracow-Bukarest-Odessa line;

3° The Belgrade-Serajevo-Adriatic line (Neum Klek or Spalato).

For the purposes of this investigation we may include among new States the Baltic countries, omitting, however, Finland, whose report records no special change during the war, at least as regards communications and transport by rail. On the other hand, the reports dealing with Lithuania, Latvia and Esthonia are full of interesting details.

Lithuania, which has an area of about 32 800 square miles (three times that of Belgium) and a population of 4 500 000, has 1 193 miles of standard-gauge railway (186 of which were laid during the German occupation) and 746 miles of narrow-gauge lines, part of which are not at present in operation. Some of these, such as the Kovno-Vilna line, which is a section of the Berlin-Petrograd line, the Vilna-Dvinsk line on the Vienna-Petrograd route, etc., are international lines.

During the battles between the Russian and German armies during the Great War and the retreat of the Polish troops after their last engagement with the Russian army, 30 % of the stations were destroyed. Such stations as were not destroyed are in need of repair; the bridges are temporary wooden structures, and are being rebuilt.

The plans for the future include, in addition to the work of reconstruction which we have mentioned above, the laying of new lines, among which may be mentioned the Memel-Telsiai-Chavli and the Kovno-Polonga standard-gauge lines, and 248 miles of narrow-gauge line, and at the same time the removal of lines which, laid for strategical purposes, are no longer of any economic importance.

As regards Latvia, the railway system there consists of 1 166 miles of broad-gauge line (706 of which are Russian gauge) and 605 miles of narrow-gauge lines of different dimensions.

The engineering works and buildings were largely destroyed during the war, so that the reconstruction of the system will entail heavy expenditure.

Plans for the future include the laying of new narrow-gauge lines.

Esthonia possesses 616 miles of railway, 405 of which are Russian gauge (1 m. 524 [5 feet]) and 211 are narrow gauge (0.75 m. [2 ft. 5 1/2 in.]). On these lines there are numerous bridges which were to a great extent destroyed during the war, including the bridge over the Narev, 463 feet in length.

New lines are at present being considered, such as, for example, a through line from Reval to Moscow, the concession for which has been granted to Esthonia under the Moscow Treaty, and another which, running from the extreme west of the Island of Oesel, will connect the towns of Pernau, Wiljandi and Tartu and have its terminus at Smolensk, and will thus form the most direct link between the Baltic on the one hand and the South of Russia, the Donetz Basin and the Caucasus on the other.

The new State is counting on the assistance of foreign capital for the construction of these lines.

Attention must be called to the fact that the shortage of coal experienced during the war gave a great impetus to the enquiry in many countries into the application of electric traction to railways.

France drew up a scheme to electrify 5 526 miles of main line, the necessary power being derived from the Upper Dordogne and the Rhone.

In Spain the electrification of the Col de Pajeras line, which connects the Asturian system with the lines in the interior, will shortly be commenced.

In her report, Sweden supplies no information on this subject, although she has developed electric traction on her railways to a remarkable extent.

In Switzerland considerable progress has already been made in carrying out the plans for the gradual electrification of the whole system of the federal railways — *i. e.*, 1 790 miles of line. The necessary work has been completed and electric traction is employed on a section of the St. Gothard line, 57 miles in length, and on the Bern-Thun (20 miles), and Brigue-Sion (34 miles) lines. The development of the necessary hydraulic and electric power is a very heavy burden on the federal railways. The cost of installing the two central power-stations on the St. Gothard line is estimated at 50 million francs; the estimates for the Barberina power-station in Valais

amounts to 37 million francs. At the end of 1920 the expenditure on power-stations, conduits and rolling-stock had already amounted to 146 millions; a further sum of 52 million was included in the 1921 budget.

Austria has also prepared electrification schemes. As a result of the new frontiers determined by the Treaty of St. Germain, the Austrian Republic has been deprived of rich coal-producing districts, so that she is now dependent on Germany for this form of fuel. The desire to find a remedy for the very serious situation prevailing in the new State in this respect has led it to consider the question of substituting electric traction for steam traction by utilising the water-power of the country.

The Arlberg line was the first chosen for conversion; the electrification of the Innsbruck-Salzburg line, the Schwarzach-Saint-Veit-Spittal-Lake Millstatt section of the Tauern line, and others, will follow shortly.

Italy, it may be said, occupies the leading position in the electrification of railways; as early as 30 June 1914, electric traction was employed on 186 miles of line; on 30 June 1920, this number had increased to 286; work was in progress on 124 miles, and the complete plans provide for the conversion of at least 3 730 miles of main line.

Latvia has also drawn up a scheme for electrifying her railways by employing the very considerable water-power at her disposal. The Dangava can supply 396 000 H. P.; at Dole, near Riga, there is another fall of 65 000 H. P. and others again are found at Kegum, 85 000 H. P.; at Ailazande, 36 000 H. P.; Koknije 120 000 H. P.; Aivnaja, 72 000 H. P.; and Jebrabmeets 18 000 H. P.

But if electric traction is regarded by countries ill provided with coal as a remedy for the difficulties experienced in securing supplies of fuel, its technical advantages induce even countries which have coal at their disposal to adopt it. Such is the case, for example, in Great Britain. The English Minister of Transport intends, it is said, to encourage railway companies to employ part of their capital in electrifying their lines, particularly suburban lines. As experience has shown in a large number of countries, these lines may easily be electrified : traffic increases, and the capital thus invested brings in ample return. A commission of engineers is to investigate the means of solving the group of questions relating to the development of electric traction, especially from a point of view of the transfer of stock from one system to another and the employment of the same stock on different lines.

It is even believed that the electrification of railways will assist in solving the problem of removing the working population from the great congested urban centres.

IV. — Rolling-Stock. — Traffic. — Rates. — Fuel. — Financial position of the systems.

As regards rolling-stock, we have already seen that in all belligerent countries traffic suffered from the excessive demands on the available means of transport. It will be well to call attention to a few special points.

Germany, owning an abundant supply of rolling-stock in excellent condition, was compelled, on account of the wide area over which hostilities were waged, to subject her stock to very heavy strain, while she had neither the time nor the means to undertake any but the most urgent repairs. The blockade imposed by the Allies deprived her of the most essential raw material, so that she was compelled to use spare parts manufactured out of other material (iron boilers and fire boxes, metal chairs and insulators of poor quality). The use of this inferior material increased the repairs required. The locomotives had necessarily to use fuel of poor quality and deteriorated rapidly.

While repairs became more numerous and urgent, the output of the workers

declined, especially in the case of factory hands. The German report lays special emphasis on this circumstance, which was common to all countries, and which is ascribed to the introduction of the eight-hour day, to the abolition of piece-work, to the employment of inexperienced mechanics and workmen to take the place of the experienced staff which had been called to the colours, and to the lack of foremen and consequently of supervision.

Political troubles, constant strikes and, in the case of Germany, the shortage of food during and immediately after the war, still further reduced the output of the workers.

Germany, however, points out that, as a result of the energetic action taken, the situation has improved and that last piece-work was reintroduced.

It is difficult to estimate in figures the difficulty caused by the absence of stock sent to the repair shops. But certainly the percentage of rolling-stock thus immobilised is greater now than before the war.

According to the Italian report, the percentage of temporarily unserviceable stock had increased, on 30 June 1920, as compared with 30 June 1914, by 11.3 % for locomotives, by 7.4 % for passenger coaches, by 2.7 % for luggage vans, and 5.6 % for trucks.

In Czecho-Slovakia, while before the war the locomotives laid up for repairs represented only 18 % of the total, they amounted at the time of the Armistice to 40 %; these figures then fell to 37 % in 1919 and to 32 % in 1920. Passenger coaches undergoing repairs amounted to 33 % of the total stock at the beginning of 1919, to 14.4 % at the beginning of 1920; trucks requiring repair represented at the two periods mentioned 14 % and 7.8 % respectively.

In Hungary the percentage of locomotives laid up for repairs was 62 % in November 1920, and fell to 45 % in 1921; the percentage of passenger-coaches undergoing repairs was 26 % in 1920 and 27 % in 1921, though general conditions had everywhere slightly improved; the percentage of trucks under repair fell from 27 % in 1920 to 17 % in 1921.

The percentage of locomotives thus immobilised is greater than that of other rolling-stock. This fact can easily be understood, as locomotives require greater care than ordinary rolling-stock to keep them in good working condition.

Switzerland, on the other hand, is in a special position. The falling-off in traffic has left her with a surplus of locomotives and passenger carriages, and she has been able to lease a certain number of locomotives to foreign railways. The number of trucks, however, is now inadequate, because in consequence of the scarcity of rolling-stock on foreign systems, the large quantities of goods imported into Switzerland through the Mediterranean seaports have had for a long time to be carried exclusively on Swiss trucks. It therefore became urgently necessary to increase the number of Swiss goods trucks. The number of these trucks rose from 19 300 in 1913 to 25 000 in 1920.

Poland, Czecho-Slovakia, the Serb-Croat-Slovene State, succession States of the Austro-Hungarian Monarchy, together with the Austrian and Hungarian Republics themselves, lay special stress, in addition to the other difficulties which are common to all countries, on the inconvenience which they experience from the fact that the allocation of the rolling-stock which formerly belonged to the Austrian and Hungarian railways has not yet been carried out. (This allocation is to be effected by a special commission set up under article 318 of the Treaty of St. Germain.) For this reason the countries referred to do not yet possess any rolling-stock which may be properly called their own, except such stock as they have built or acquired since the war. They have only a common pool of stock, which is very small in comparison with its previous dimen-

sions. The locomotives and trucks sent into the zone of hostilities fell into the hands of the enemy, and in addition some of the trucks belonging to the common pool are immobilised in the country which temporarily holds them, and which is careful not to allow them to pass over its frontiers. The country which has suffered most from these circumstances is Czecho-Slovakia, which, as, above all, an exporting state, sends beyond her frontiers more trucks than she receives in return and only recovers empty trucks very slowly.

The pool of trucks should, according to the Czecho-Slovakian report, remain at the disposal of all the sucession States: and, indeed, each of these States, being in urgent need, has come to regard the stock in its territory as belonging to it or at least as intended in the first place to serve its own industry. Thus, as difficulties are placed in the way of returning empty trucks, exporting countries state that they are in an intolerable position; on the one hand they are compelled to send their trucks over the frontier to avoid unemployment in their industries, and on the other hand they find their home traffic placed in jeopardy by the steady disappearance of trucks from their territory.

The prevailing uncertainty as to the ownership of stock leads, further, to neglect in its upkeep. Many trucks in need of repair obstruct the lines and remain unused. It is absolutely necessary not only to expedite the allocation, but to return to the former strict system of exchanging stock so that it will be easier to use it in common. The stock indeed is not insufficient in quantity, but it is somewhat worn out. This comparative shortage is the main cause of the transport crisis from which Central Europe is suffering.

Czecho-Slovakia has a fair number of large workshops; she intends to build others, and will thus soon be in a position to deal with the situation. The Serb-Croat-Slovene report states that the amount of rolling-stock belonging to the country is unknown, but the quantity is certainly not great and the stock is in very bad condition. Moreover, as there are no workshops for the repair of carriages in the national territory, the Serb-Croat-Slovene State is compelled to have recourse to neighbouring countries, which only carry out the orders after long delay and on very burdensome conditions.

Even the countries where railways are most highly developed and which suffered least from the war are experiencing the difficulties which arise from scarcity of rolling-stock. On 30 June 1919, England had on her 16 principal railways 17 743 locomotives, or 1 186 fewer than at the end of 1913. These 16 railways had 650 606 carriages actually running on 30 June 1919; that is, 45 315 fewer than on 31 December 1913. This notable falling-off in the rolling-stock coincided with an increase in the volume of transport and the reduction in the working day. In England it gave rise to a congestion of traffic on a scale which was precisely similar to what occurred in all countries during the period immediately following the war. Naturally the difficulties involved in the reconstruction of stock were speedily overcome in highly developed industrial countries. But the crisis in connection with rolling-stock will last longer and be more difficult to surmount in countries whose resources are exhausted, especially in the countries of Eastern Europe, which are compelled to obtain locomotives and trucks from foreign countries.

The enquiry into the volume of goods traffic during and after the war should lead to a definite conclusion on the question whether, as many circumstances seem to show, the war, by giving an impetus to industrial activity and by promoting intercourse between the nations which were divided into two great alliances, has been responsible for an increased development of trade.

Unfortunately the great uncertainty

which prevails on this subject cannot be dispelled by the figures given in the reports. The statistics dealing with the war period properly so called are of no great value in our enquiry. Transport, indeed, increased during this period, but the causes of the increase were essentially of a temporary nature, and a great deal of trade necessary in the conduct of the war for the supply of the civilian populations with food ceased at the Armistice or shortly after. As to the post-war period, it has been marked by such economic upheavals that all conclusions are rendered of little value by the special conditions in which the events occurred. We are dealing with dismembered groups of States, new countries under unstable political systems, regions in a state of anarchy, a vast empire completely isolated from the economic world, and monetary systems in a state of incredible disorder; all these factors have modified the previous situation and make it impossible to compare it with the present.

We are impressed among other things by the amazing instability of economic conditions. Immediately after the war there was a great increase in activity, but a crisis suddenly ensued which put a stop to this forward movement. Further, events have naturally taken different courses in neutral countries, conquering countries and conquered countries.

As has been very truly pointed out in certain reports, all this makes it impossible to form any very clear idea of the true position at present and the probable development of events in the near future.

It is not yet possible for us to arrive at any definite conclusions as to the development of transport since the war, and the influence which it has exerted on the volume of trade. Only at a later date, when the storm caused by this disaster, which is without precedent in history, has subsided, and a new order has been established, will it be possible to form a correct estimate of the results of the war on transport, which is, as it were, a synthesis of all human activity. The provisional conclusions which may be drawn from the following figures must, therefore, be accepted with all due reserve.

When we examine the subject matter of the reports we are impressed by the heterogeneous nature of the statistical information supplied by the various States. The units of measurement which ought to be applied to transport by rail are the passenger-kilometre, and the ton-kilometre, which combine in one statement the whole idea of the traffic handled and the distance covered It is, however, only in countries with a railway organisation of long standing and with a competent statistical service that it has been possible to produce these figures. For the other countries we must rest content with approximate estimates of transport, such as the distance covered by trains, the number of passengers carried, the nature of the goods shipped, and, in the last analysis, the receipts which would be derived from this traffic calculated at the same rates.

We may note further that new countries which have come into existence as a result of the dismemberment of their States possess no pre-war statistics regarding their territories, and that consequently it is impossible to institute a comparison with the present position; further, the new railway administrations, organised in troubled times unfavourable to systematic enquiry, are without the necessary means of carrying out investigations.

Thus, in spite of our best efforts it has not been possible to outline very clearly or draw any very precise conclusions from the general account of the development of transport since the war.

If we begin with Western Europe we note that in England the total number of passengers carried in 1919 by the sixteen principal railway companies

was 974 000 000, or an increase of 19 % as compared with 1913.

The receipts from the carriage of goods rose in 1919 to £5 000 000 — an increase of 7 % as compared with 1913, basing the calculations on the tariffs then in force; but this percentage rose to 20 if the transport effected on behalf of the Government is taken into account. The nature of the traffic, however, has slightly changed; on the one hand long-distance consignments have increased, and on the other, goods previously carried by coasting vessels have been absorbed by the railways.

Belgium calls attention to the fact that, out of an average of 31 passenger trains running daily on each line of her railway system, only 18 were running in 1921. The conclusion must not be drawn that the number of passengers has declined in the same proportion; as a matter of fact the number of passengers, which fell from about 204 000 in 1913 to 102 000 in 1919, rose to 80 000 for the first five months of 1920. In July 1914 the number of international trains passing through Belgian territory was 60. In March 1921 only 35 of these had been restored, with shorter routes and fewer passengers.

Quite apart from the war period strictly so-called, it is clear that the mere fact of strained international relations must, in the case of a transit country like Belgium, inevitably react on passenger traffic, but everything seems to point to the fact that the situation will soon become normal again.

In 1913 the volume of goods traffic was on an average 30 trains per day for each line of the whole system; in January 1921 the number of goods trains was only 20. These facts represent an actual decline in the carriage of goods. While before the war 20 000 trucks per day were in use, in 1919 and 1920 the figures fluctuated between a minimum of 10 000 and a maximum of 18 000. In 1921 the industrial crisis reduced the number to 15 000; goods carried amounted to about 5 500 000 tons in 1914, they fell to 700 000 immediately after the armistice, and rose to 4 000 000 tons in 1920.

In Luxemburg, which is also essentially a country for transit traffic, the number of passengers fell from 8 000 000 in 1913 to 5 500 000 in 1920, and goods from 8 000 000 tons in 1913 to 4 000 000 in 1920.

In France the distances covered by passenger trains over the whole of her railway systems declined from 152 860 000 miles in 1914 to 79 537 000 miles in 1920, and the distance covered by goods trains from 95 693 000 to 83 265 000 miles. The number of passengers decreased from 541 to 527 millions; but as the result of the increase in the average distance, a total of 22 milliards passenger-kilometres was reached in 1920, as against 19 milliards in 1913. On the other hand the transport of goods declined from 31 756 million English ton-miles to 29 783 million.

It will be at once noticed — and later figures will confirm the truth of this general statement — that the war led to a fuller employment of trains. The load was increased and the speed reduced with a resulting increase in the traffic unit both for passengers and for goods. These are signs of more economical working. It may, therefore, reasonably be predicted that when economic equilibrium has been restored these factors may contribute to counteract the effects of the general rise in prices on railway rates. All the reservations we have made as to the conclusions to be drawn from a study of the present situation apply to this forecast.

In the case of Spain, a fairly large increase in the annual number of travellers carried is to be noted. The number rose from 50 000 000 before the war to 84 000 000 in 1920. With regard to goods, the figures rose from 29 000 000 tons to 35 000 000 tons. The reason for this increase is clear : Spain was a

country poorly developed as regards railways, and her trade was not only never interrupted but was actually improved and increased by the war.

In Central Europe, Sweden supplies no comparative statistics, but there is good reason to believe that their traffic developed to a marked degree, especially as regards the export of ores.

Between 1914 and 1919 Norway records an increase of 56 % in the number of passengers, and 19 % in the tonnage of goods. In Denmark, traffic also developed to a remarkable extent between 1913 and 1920. The number of passengers rose from 23 000 000 to 31 000 000 per year, and goods from 6 to 8 million tons.

As regards traffic, Switzerland did not enjoy the same favourable conditions as other neutral countries. In May 1914 — the date of the opening of the National Swiss Exhibition — the time-tables showed a large number of trains. Passenger traffic, which had steadily developed up to that period, was interrupted by the declaration of war; the mobilisation of the army led to a reduction in the number of trains available for the civilian population, and when circumstances would have permitted an improvement in traffic conditions, the shortage of coal was an obstacle. Passenger traffic through the country, or coming from abroad, came to a complete stop. On certain lines, such as the Simplon line, traffic ultimately fell to 2 % of the normal figures.

Since the restoration of peace, passenger traffic, which is of such great importance to Switzerland, has continued gradually to improve. As is pointed out in the report, however, there are still certain obstacles in the way of the resumption of normal traffic. These obstacles are connected with the difficulties arising from the issue of passports, customs formalities, the unsatisfactory economic position of travellers from certain countries, the great increase in fares, and the fact that former political and economic relations between the various countries have not yet been fully restored.

In spite of these difficulties the number of passengers, which had fallen, from 128 000 000 in 1913 to 103 000 000 in 1918, rose to 114 000 000 in 1919. The amount of goods carried remained practically stationary, but the nature of the traffic underwent a change. Imports increased as compared with exports; moreover, like all countries without an outlet to the sea, Switzerland has experienced rather serious difficulties in securing supplies.

Train traffic in Germany diminished in 1920.

In Germany rail traffic decreased by 35 % as compared with 1913. These figures apply to the Prussian and Hessian railways, but the report states that it may reasonably be taken as representing the position of the whole German railway system. The railways are short of resources, and traffic has fallen off as a result of the gravity of the economic situation. The report gives no further details on this question.

In January 1921 the distance covered by passenger trains in Austria was only 34 % of the pre-war figures. Between 1919 and 1920 the transport of goods declined, but no precise figures have been given. On the outbreak of war, passenger-trains on the Government railways in Hungary covered 112 470 miles daily. During the war these figures declined to an amazing extent, and fell almost to zero during the revolutions. A return is gradually being made to former conditions, and in 1921 the distance covered daily was 12 430 miles, or rather more than 10 % of the pre-war distance.

There is a considerable volume of passenger traffic in Czecho-Slovakia (113 000 000 persons were carried in 1919, as against 153 000 000 for the whole Austrian system in 1913), but no detailed particulars are supplied which will enable us to determine to what extent

traffic has increased within its territory since the war. It would, moreover, be difficult to provide such information, as Czecho-Slovakia is a new State which possesses no statistics of its own for the pre-war period. As regards goods, the quantities carried in Czecho-Slovakia amounted to 33 000 000 tons in 1919, as against approximately 36 000 000 tons in 1913 for the whole Austrian system.

The statistics with regard to transport in Poland do not permit of any comparison being made with the pre-war period. The same statement may be made as regards Roumania, Finland, Esthonia, Lithuania and Latvia.

In the Serb-Croat-Slovene Kingdom 445 trains were running daily before the war; this number was reduced by more than half in 1920 (206); statistics regarding the number of travellers and the amount of freight are lacking.

In Bulgaria the number of trains was 39 678 in 1911 and 41 245 in 1919-1920. The number of passengers carried, which in 1911 had been 3 1/2 millions, rose to about 5 millions in 1920. Goods, on the other hand, declined from 2 000 000 tons to 934 000.

The Greek statistics do not give figures for the Macedonian railways. Comparative tables with regard to Greek railways strictly so-called reveal the fact that the distance covered by rolling-stock in 1919 shows, as compared with 1914, an increase of 66 % for standard-gauge lines, and a decline of 13 % for narrow-gauge lines.

Passenger traffic in 1919 was greater than in 1914 by 14 % on standard-gauge lines and 11 % on narrow-gauge lines. Goods traffic by slow trains was 9 % greater on standard-gauge lines and 1 % greater on narrow-gauge lines.

The slow goods traffic was 9 % greater on the standard-gauge lines and 1 % greater on narrow-gauge lines.

In conclusion, it may be said, subject to all the reservations necessary in the case of such deductions, that in countries in which the former economic organisation has not been destroyed, or which have regained economic stability, or are on the point of doing so, traffic has increased; in all other countries it has decreased, and some time will certainly elapse before it will resume its former proportions.

It was necessary to undertake a special enquiry as to the amount and price of the fuel available, for one of the features of the transport crisis during and after the war was precisely the scarcity of fuel for railways.

Even in England, which supplied half Europe with coal, prices increased four-fold. Large coal for locomotives, which was quoted in 1918 at 20 sh. 2 d. f. o. b. rose to 80 sh. in December 1920. Prices, as is generally known, have fallen considerably since that date. The railways of the United Kingdom consumed before the war 13 000 000 tons yearly — a consumption which remained practically constant.

In France the railways in 1913 consumed 8 million tons at an average price of 22 fr. In 1920 the consumption was rather higher: 9 million tons, and the price rose to 238 fr. per ton. The fuel consumed in 1920 came from Germany (Ruhr and Saar), England, America, and the French mines themselves.

In Luxemburg, Saar coal before the war cost 20 fr. per ton; in 1920 the price rose to 100 fr.

In Spain, coal costs from 90 to 125 pesetas per ton.

Sweden used foreign coal only to a very slight extent, and this coal cost on an average in 1914, 16 crowns per ton.

Norway also imports English coal; while she paid 20 crowns for it in 1914, she paid prices varying from 90 to 136 crowns from 1918 to 1921.

In Denmark, prices rose from 20 to 121 crowns.

Up to 1918, Switzerland drew her supplies of coal almost exclusively from Germany, as before the war, but towards the close of 1918 Germany discontinued her supplies and recourse had to be had

to Belgium, America and England; in 1920 almost all the coal consumed came from America.

The average price per ton, which was 27 fr. in 1913, rose to 190 fr. in 1920. The situation subsequently improved.

The railways of the Austrian Empire were in a position to obtain the greater part of the fuel required within the country itself; the State railways, for example, bought 84 % of their annual supply from mines within the country, and imported the remaining 16 % from England and Upper Silesia. As these supplies were obtained under contracts, it was possible to check the quality, and thus good coal was obtained.

As such measures cannot be adopted at the present time, the quality is inferior and the consumption is greater, thus, while 2 500 000 tons were sufficient before the war for haulage on all the lines of Austria, within her present limits 3 750 000 tons are now necessary for the same work.

After the dismemberment of former Austria, her supply of coal was seriously imperilled as a result of the loss of productive areas, and these difficulties were more serious as communication with foreign coalfields, particularly Czecho-Slovakia, Germany and Poland, were at this period completely interrupted. In consequence of negotiations, especially with Czecho-Slovakia and Germany, the supply of coal has improved to some extent.

The price of coal from the mines of the country varied before the war from 13 to 17 crowns per ton; after the war the price of Czecho-Slovak lignite rose to 135 Czecho-Slovak crowns per ton; Ostran coal to 424 crowns; Upper-Silesian coal to 304 marks; native Traunthal coal to 917 Austrian crowns; and Graz-Flach lignite to 889 Austrian crowns.

The scarcity and high price of coal are one reason why Austria limits the number of trains running on her lines.

In peace-time Hungary extracted from mines within her own territory 76 % of the coal which she required; the remainder was obtained abroad, particularly in Prussian Silesia. The amount which she requires at present is 141 000 tons per month; the position at the time when her report was drawn up was such that her requirements were not completely met. The report supplies no information as to prices, but they cannot differ greatly from Austrian prices.

Germany, which is a coal-producing country, states that she also is suffering from a shortage of fuel, owing to the supplies which she is bound to deliver. This growing scarcity of fuel is accompanied by a steady decline in quality.

As an example of the scarcity of fuel, the report points out that the railways, which in 1914 held a stock for 95 days, later held only enough for nine days or even five days.

The use of coal of poor quality damages the locomotives and leads to an increase in consumption. In 1914 the consumption of the German railways per locomotive-mile slightly exceeded 49.7 lb.; in 1919 the consumption for the same unit rose to 74.5 lb. and even at a later date to 177.40 lb. (it is probable, however, that the load drawn by the locomotives increased also).

In 1913 Germany consumed 16 000 000 tons of coal, including some lignite, which cost 13.20 marks per ton, excluding freight. The total consumption has fallen off slightly (consumption per unit has increased while the number of trains has diminished), but the price rose to 254 marks excluding freight. 17 % of the coal used is obtained from the Ruhr basins, 21 % from Upper Silesia and the remainder from Lower Silesia, Saxony, and other mining areas.

The Italian railways consumed, before the war, about 2 200 000 tons of English coal of high quality from the Cardiff and Newport coalfields; but during the war it was necessary to resort to coal of all kinds, with the result that the total consumption in 1920 rose to 3 400 000 tons,

including a small quantity (108 000 tons) of native lignite.

English coal of good quality cost in 1914, including freight, 36.33 lire per ton; in 1919 the average price rose to 397 lire; it reached a maximum of 695 lire in November 1920. Certain subsidiary Italian systems paid for English coal as much as 800 lire per ton, c. i. f. Genoa or other Italian ports.

It should be pointed out again that in 1921 the price of coal fell considerably.

The Czecho-Slovak railways required in 1920 1 000 000 tons of coal and 3 1/2 million tons of lignite. Consumption per unit has increased by about 50 %, chiefly as a result of the poor quality of the coal used.

Before the war, local industries, especially in Bohemia and Moravia, drew their coal largely from Prussian Silesia. As the amount of Silesian coal has considerably declined, it has become necessary to allocate to these industries, which as a rule cannot use coal of inferior quality, native coal of high quality; thus nothing but native coal of poor quality remains for use in locomotives, and on that account the engines are being damaged. Two-thirds of the quantity consumed are supplied by the lignite fields of Northern Bohemia and the remainder by the Ostrava-Kervin Basin (Teschen country), by the Falknow Basin (North-West Bohemia) and by other smaller fields in the country.

Pre-war prices were 5 crowns for lignite and 14 crowns for anthracite, but in 1919 prices had risen to 52 Czecho-Slovak crowns for lignite and 115 for anthracite, and in 1920 to 160 and 380 crowns.

Turning to Eastern Europe we note that the results of the shortage of coal are still more striking.

Before the war the Polish railways drew their supplies of coal from Upper Silesia; for reasons which are easily understood, deliveries from Upper Silesia have since the war been very irregular.

In Poland, as in the whole of Eastern Europe, wood is largely used as fuel for locomotives. The consumption thus amounts to 4 944 320 cubic feet of wood per month, in addition to 300 000 tons of coal. The report gives no information as to prices.

As the Serbian mines were burned or destroyed during the war, the Serb-Croat-Slovene Kingdom is without this source of supply; it now obtains its supplies from the mines of Bohemia and Herzegovina (Krek and Onica, Zgosca-Breza and Mostar).

The annual consumption on the Serb-Croat-Slovene railways is about 250 000 tons. The price per ton, which before the war was about 10 dinars, is now 120 dinars.

Before the war Roumania consumed only 86 000 tons of coal, which cost her 37 lei per ton, but she used 220 000 tons of lignite at 15 lei, 8 225 000 cubic feet of wood at 9 lei, and 176 tons of petroleum. She consumes to-day 198 000 tons of lignite, costing from 116 to 212 lei; 5 000 tons of coal at 356 to 426 lei; 118 000 tons of petroleum at 500 lei, and about 70 620 000 cubic feet of wood at 100 lei. This consumption is likely to increase as traffic is restored.

During 1920 the total consumption of coal on the railways in Bulgaria amounted to 333 000 tons, all the supply being drawn from the State mines at Fernik. The price, which was 80 to 100 leva, has now risen to 120 leva per ton.

Greece uses English coal. In 1914, 11 000 tons, costing 37 drachmœ per ton, were consumed on the standard-gauge lines.

In 1919 the consumption rose to 37 429 tons, including 2 400 tons of native lignite and 1 000 tons of wood. The fuel used in 1919 was obtained from various sources, and the average price was 270 dr. for coal, 140 for lignite and 72 for wood. The consumption per unit increased.

Among Baltic countries Esthonia points out that in 1920 she encountered

serious difficulties in obtaining supplies of fuel. For that reason she was compelled to resort to wood during a great part of the year and she has begun to use native coal, beds of which are being worked by the railway administration itself.

Lithuania is also experiencing difficulty in securing the small quantity of coal which she requires (120 to 140 thousand tons per year) and must therefore have recourse to wood. The same conditions prevail in Latvia, but to conserve her forests she intends, as has been shown already, to develop electric traction.

The conclusions which we feel entitled to draw from the above facts relating to fuel are optimistic in the sense that the coal crisis on the railways, which was a direct result of the state of war, is already over. Exports have been resumed, and henceforward no country need be without a quantity of fuel adequate for her needs.

Prices remain high as compared with pre-war figures, but this circumstance is to be explained chiefly by the depreciation of money.

The essential causes of the increase, reckoned on a gold basis, are the same as those of the general rise in prices, and are closely connected with labour conditions.

A comparison of the present prices in the various countries would be meaningless, as these prices are shown in different currencies which have depreciated in varying degrees.

We have already mentioned another conclusion of a general nature. The consumption of fuel per train-kilometre has greatly increased. This increase is due to two causes : one, which is of a temporary nature, is the poor quality of the coal used; the other, which, it may be predicted, will prove permanent, is connected with the development of a characteristic feature in the technical progress of the railways, which has received considerable impetus from the necessities of the war : the increase in the weight of trains.

In Europe, before the war, as a result of the abundant supply of labour and the facilities for obtaining supplies of coal, it was possible to work the railways with a large number of trains and small loads. On the other hand, in America, where more powerful engines were used, it was the practice to concentrate traffic in heavy trains. Experience has shown that the latter system is preferable from the point of view of the cost of working; the crisis of the war, as we have already stated, encouraged this tendency, which will very likely prove permanent.

We may also mention the example set by the Americans in France, where they operated the lines giving access to their ports of disembarkation according to their own methods. The increase in the weight of goods trains may therefore be regarded as one of the valuable results of the war; this increase tends to reach the same proportions as in America; it leads to reduction in freight rates, but involves the introduction of the technical improvement to which we have already referred. This improvement, which was under consideration before the war, began with the use of the continuous brake on goods trains inaugurated during the war by Germany when she adopted the Kunze-Knorr system. If this system should not be accepted by the States Members of the League of Nations, Germany, under article 370 of the Treaty of Versailles, would be obliged to alter it, for the type of brake for goods trains is essentially an international question on account of the constant exchange of rolling-stock between different systems and different countries. In any case this is a question which must be settled at an early date.

Germany makes no reference to this innovation in her report. Sweden alone has stated that she was about to equip her goods trucks with the Kunze-Knorr

continuous brake which was selected by Germany.

In all countries without exception, railway tariffs increased considerably during the war and even more during the period immediately following it. During the long period of peace which preceded the war, a general and constant tendency to reduce railway tariffs had become apparent. Generally speaking, this reduction did not apply to transport of all kinds; only certain classes of goods had the benefit of reduced tariffs, which, while lowering the average level of prices, largely developed traffic. Reduced fares led to an increase in passenger traffic, and special tariff regulations applying only to classes of goods with possibilities of development improved conditions in goods traffic. This tendency was the expression of a sound economic idea, beneficial alike to the public and to the railways. The latter, indeed, as a result of the increase of freights, which were not very remunerative but easily handled, compensated for the increase in their general expenses. If, moreover, general expenditure increased on account of the inevitable development of plant and the increasing complexity of the administration, gross expenditure, on the other hand, diminished as a result of the constant progress made in technical matters which permitted the employment of more powerful and more economical engines, trucks of large capacity, and, in general, of improved equipment.

This tendency towards reduced tariffs was encouraged by the fact that the working of the railways was gradually passing under the control of Governments which were more inclined to make experiments in reducing tariffs even without knowing beforehand what the result would be. Keen competition of producing countries in the world's markets was the impetus for an attempt to overcome the obstacle presented by customs duties by means of reduced freight rates. Briefly, dumping was always a decisive factor even in railway rates. The economic upheaval caused by the war not only checked these tendencies but brought about a movement in the opposite direction, and led to an enormous rise in the cost of transport. We are of opinion that it would be interesting to estimate the extent of these increases in rates. The questionnaire has supplied us with the figures which we shall classify and summarise below. But at the outset it must be noted that these statistics are of comparatively small value in the matter of railway tariffs. As a result of the differentiating measures to which we have alluded, these tariffs have become so complicated that they invariably include a large number of rates for different classes of goods or passengers or different kinds of transport (through trains or omnibus, slow or fast trains, complete truck-loads or small consignments), and vary according to the competition between different companies and between railways and other means of transport.

As a general rule, the increase in tariffs manifests itself first in the abolition of existing facilities (return tickets, circular tickets, season tickets, etc.), and in higher rates for Sunday tickets and increased State taxes.

The next step has been a systematic increase in rates, strictly so-called — *i. e.*, all rates were raised according to complicated rules — that is to say, by applying different rates according to the distance and the method of transport.

As a general rule the proportion of increase was lower for cheaper forms of transport, the increase in the cost of third-class tickets being less than for first- and second-class tickets.

In certain countries the increase in the freight rates was less in the case of goods where the rise in prices had been greatest, such as fuel or essential articles such as food-stuffs. What we have said is enough to show that the variations in tariffs can only be determined by reference to averages or to particular cases,

but no matter which method is employed, the information thus obtained does not give an accurate explanation of the facts, for in order to form a correct idea of the subject as a whole, it would be necessary to make a comparison of the various classes of transport considered separately.

As will be seen, the rates of increase vary in different countries and are naturally much greater in countries with a depreciated currency than in those where the currency has remained sound. But these differences are for the most part only apparent, since in a country where the currency has remained stable an increase of 10 % would be exactly equivalent to an increase of 100 % in a country where the currency, during the same period, had depreciated to a tenth of its value.

To sum up, it may be stated that a real increase in the cost of operating railways has occurred in all countries as a result of the adoption of the eight-hour day, the falling off in the discipline of the personnel, the scarcity of the materials employed on the railways — all of which causes have contributed in almost the same proportion to the rise in working expenses. Moreover, the difference in the amount of the rise depends on the attendant variations in the monetary unit in which the rise is expressed.

All such increases, which are the result in different countries of a whole series of badly co-ordinated and, occasionally, overlapping measures, render any investigation of the question difficult.

It may further be noted that a certain lapse of time always occurs between the appearance of the causes leading to a rise in prices and the increase in tariffs. Is is natural, indeed, that Governments should feel unwilling, where the railways are worked by the State, to adopt, or, where they are worked by private companies, to sanction, increases in tariffs which, they have reason to fear, will react on the cost price of the necessaries of life. This delay in raising rates has gravely imperilled the financial position of the companies. For this reason their balance-sheets show large deficits which would have been wholly or partly obviated if tariffs had at once been raised to meet the costs of working.

The English report points out, without any comment, that an increase of 75 % in the case of passenger traffic and of about 112 % in the case of goods traffic has been made in pre-war rates in England.

It is desirable to compare these figures with those of another country whose currency has remained practically at its pre-war value : Switzerland. The Swiss report shows that, apart from the abolition of all tickets at reduced rates, which was adopted about the end of 1915, the last rise in tariffs, dating from 1 August 1920, brought the increase up to 55 % for 1st and 2nd class single tickets and 45 % for 3rd class tickets.

Goods rates have been raised several times since 1 August 1920; the total increase represents an advance of 40 % on the pre-war tariff.

An additional burden was the abolition of most of the special rates. Finally, the Swiss tariffs were amended on the principle of applying varying rates according to the distance, with a view to securing favourable conditions for long-distance transport.

The Swiss report points out that experience has shown the necessity of putting a stop to increases in rates, for there are already signs of a falling off in the volume of traffic. Further, the increase in railway rates favours motor competition over short distances.

From the above considerations it appears that the increases introduced in the two European countries whose exchange stands highest are practically the same.

In Spain, which is another country with a high rate of exchange, the rate of

increase in tariffs, both for passengers and for goods, is 15 %, but further increases may have been adopted since the date of the report.

In France, passenger rates, including taxes, have risen 80 % for 3rd class, 84 % for 2nd class and about 89 % for 1st class. On an average, freight rates have been raised 275 %. The increase is greater for valuable goods than for goods of small value and foodstuffs.

In Belgium, the passenger rates at present in force show, as compared with pre-war figures, a rise of 120 %, the effect of two separate increases. The increases which have been applied to goods vary from a maximum of 260 % to a minimum of 150 %, according to the kind of transport and the class of goods.

In Sweden, increases in passenger rates are made on a varying scale and give a preference to long-distance journeys and 3nd class traffic; the rate thus varies from a maximum of 300 % 1st class for short distances to a minimum of 119 % 3rd class. Increases varying from 500 % for small packages over short distances and 204 % for truckloads over a long distance have also been introduced.

In Norway, passenger rates have been increased 380 % 1st class and 140 % 3rd class. The rate of increase for goods is 160 %.

In Denmark, the increase in the rates for passengers is 100 % and for goods 200 %.

As every neutral country has felt the effects of the war, none has escaped this special effect on tariffs, and only the greater or lesser depreciation of the currency has varied the rate of increase.

When we pass to Germany, we note that the rates of increase rise considerably. First-class tickets which before the war cost 7 pfennig per kilometre now cost 58.5 pfennig, and 4th class tickets have risen from 2 to 13 pfennig. The increases in goods rates amount to 900 %, the result being that freights at present cost ten times what they did in 1914. Moreover, further increases may have been decided on since the date when this report was drawn up (June 1921).

In Austria, the increase on passenger rates varies from a minimum of 929 % (3rd class omnibus trains) to a maximum of 1718 % (1st class through trains); freights, which have been raised on several occasions, have increased 6 000 %. We have reason to believe that further increases have been introduced since then.

In Hungary, passenger rates have risen, by successive increases, 800 % and freights 600 %.

Czecho-Slovakia applies the Austrian tariffs in Bohemia, Moravia and Silesia, and Hungarian tariffs in Slovakia and Sub-Carpathian Ruthenia.

In Italy, at the end of 1920 the increase in the price of tickets was about 230 % 1st class, 210 % 2nd class and 170 % 3rd class. For most kinds of merchandise the tariffs have been raised 300 %, an exception being made in the case of a few articles in general use, where the increase has been restricted to 200 %.

In Eastern Europe, no information is available for Poland, but it may be noted that on the Serbian railways tariffs were increased immediately after the Armistice by 150 % for passengers and 150 % to 700 % for goods.

Further increases in rates followed, but we have no precise information on this point; it is probable, moreover, that still further increases have since been decided upon.

In Roumania, tariffs were raised 600 % for 1st class, 500 % for 2nd class and 400 % for 3rd class. Freights increased 500 %.

In Bulgaria, tariffs were raised both for passengers and goods 400 %.

On the Greek railway system as it was before the war, passenger rates were increased 200 % and freights 280 %.

We have no information with regard to the fariffs of the Baltic States except

in the case of Latvia. The report drawn up by this country states that in 1920 passenger rates were 24 kopeks per kilometre (0.62 mile) 3rd class and 48 kopeks per kilometre 2nd class (there is probably no 1st class), and freights varied per kilometric ton from 4 kopeks to 0.72 kopek. In January 1921 these rates were increased 50 % for passengers and 100 % for goods.

In conclusion, it may be said that the increase in railway tariffs is only one of the aspects of the general rise in wages and the cost of raw material and of the depreciation of currency. It is necessary, however, to add that in countries which have suffered least from the war a certain tendency to counteract further increases is already becoming apparent in connection with transport. A beginning has even been made in cutting down these increases by restoring the old reduced scales or by disguising a return to lower rates under the name of a general reform of tariffs. Since the level of transport rates, the price of goods and the cost of labour are all interdependent, it is clear that to escape from this vicious circle a beginning should be made with the first of these factors, which can be modified much more easily than the general conditions of production, since it is more intimately connected with the control of the State finances.

The remarks which may be made on the financial situation of the railways are of the same nature as those which apply to tariffs. The net receipts of all systems, without exception, fell off during and after the war; this decline is not the result of inadequate receipts but of a great increase in expenditure which the rise in tariffs has not followed sufficiently closely. Almost all the administrations thus show a deficit in their annual balance sheets, but the amount of this deficit varies greatly in different countries. The highest figures naturally occur in countries where the currency has depreciated. It must be repeated that this depreciation to a certain extent affects the whole problem. A deficit of several milliards in a country with a currency that has depreciated greatly is not very different from a deficit of several millions in a country where the currency is on a sound basis, when regard is had to the ratio of the two currencies. Naturally the situation in those countries which were neutral during the Great War or which were on the winning side, is essentially different from the conditions obtaining in countries which were disorganised as a result of defeat.

In England, which is the standard example of a country where the railways are operated by private enterprise, the railways were under State control from August 1914 until December 1918, in accordance with agreements which guaranteed the companies the same net receipts as in 1913, and, in addition, a reserve fund to cover the postponed expenses of upkeep. The period of control lasted from 5 August 1914 to 15 August 1921. The deficit which the State had to meet during the period of control was 40 to 50 million pounds per year; this is not a very large sum when account is taken of the fact that it applies to an original capital of about 1 1/2 milliard pounds, which in 1913 brought in an interest of 4.6 % (this interest was guaranteed by the State for the following years).

In France, the general co-efficient of operation (the ratio between expenditure and income) for all the systems, which was 63 % in 1913, rose to 71 % in 1914 and 1915, to 75 % in 1916, 84 % in 1917, 101 % in 1918, 127 % in 1919 and 132 % in 1920; it may be noted that the charges which had to be met out of capital rose from 806 000 000 in 1913 to 1 444 000 000 in 1920. The decline in gross receipts, the increase in expenditure and charges on capital led to a deficit of 389 000 000 in 1914, 358 000 000 in 1915, 345 000 000 in 1916, 555 000 000 in 1917, 975 000 000

in 1918, 1 850 000 000 in 1919 and 2 580 000 000 in 1920.

On all the great systems the receipts to 1918 exceeded expenditure if the charges on capital are not included under the latter head; from 1918, the receipts were not even sufficient to meet the working expenses, strictly so-called. The expenses showed an increase of about 20 000 000 in 1918, 875 000 000 in 1919, and 1 136 000 000 in 1920. These figures are, moreover, not final, as the accounts for military transport have still to be liquidated between the State and the companies. It must further be remembered that the figures referred to above apply to an original capital of about 30 milliards of francs.

The Spanish report points out that the financial position of the railway companies is not prosperous; it adds, without supplying any figures, that the receipts from working the railways are not sufficient to cover the costs and charges on capital, so that these companies have been compelled to ask the State for relief in the form of advances, which will be repaid later, in order to meet the increase in wages and the reduction in the working day, not to mention new purchases of rolling-stock.

In another neutral country — Sweden — the net receipts from the State railways amounted to 22 000 000 crowns in 1916, whereas in 1918 there was a deficit of about 45 000 000 crowns. This deficit disappeared in 1919, in which year there was a surplus of 5 000 000, which increased to 30 000 000 in 1920. Private companies have proved successful in keeping their profits at a fairly steady level.

In Norway, where there was a deficit of 3 million crowns in 1913 (it is not stated whether the expenditure includes charges on capital), the deficit rose to 11 million crowns in 1919 and in 1920, including the allowances for the high cost of living granted to employees.

Denmark states that the financial position of her railways is sound. Still confining our attention to neutral countries, we note that Switzerland in 1913 had a surplus of about 90 million francs to meet charges on capital; the surplus fell to 30 millions in 1918 and rose to 63 millions in 1919. The capital on which interest has to be paid is 2 670 millions.

Italy is one of the countries which suffered most from the rise in the price of coal, and this circumstance reacted on the financial position of her railways. The income from the State system (575 millions) showed a surplus in 1914 of 28 millions over expenditure (547 millions excluding charges on capital); in 1920 working costs rose to 2 690 millions as against receipts of 1 797 millions; the deficit was thus 860 millions. The coefficient of operation rose from about 77 % in 1914 to 134 % in 1920. The capital exceeds 8 milliards.

The system of secondary railways and tramways also shows a marked decline in the net returns and therefore a deficit which must be made good by State subsidies.

When we turn to countries which suffered defeat in the war the deficits are found to be much greater.

In Germany, the surplus in 1913 exceeded a milliard marks — a sum which was more than sufficient to meet the charges on capital; in 1919 there was a deficit of 4 milliards (not including charges on capital), and this deficit rose to 11 milliards in 1920, with an addition of 2 1/2 milliards for the interest on capital.

These statistics apply to the State railways at present administered by the Empire; as for privately owned lines, they are of practically no importance.

In the present Austria, railways are for the most part owned by the State. In 1913 the 11 986 miles of railway belonging to the State yielded a net profit of 190 million crowns; the charges on capital entailed an annual expenditure of 247 millions. The actual deficit when all the factors were taken into account

was 51 millions. As regards the present Austrian railway system, the extent of which is only one-quarter of the former system (2 783 miles instead of 11 986), the deficit was 247 million crowns in 1919 and 3 589 million crowns in 1920.

The situation of the Hungarian State railways is, comparatively speaking, sound. Before the war, the net profit on the railways was 90 million crowns. It rose to 106 millions in 1918, and it must have increased still further during the following years, but the charges on capital are not included in these figures. In 1913 the net profit on the Hungarian southern system (Südbahn) was 9 millions, in 1918 it was 15 millions; but in 1919 and 1920 there was a deficit.

Czecho-Slovakia estimates that the deficit on her railways amounted to 240 million Czecho-Slovak crowns in 1919; this deficit rose to 625 millions in 1920; it is thought, however, that the deficit will be reduced to 265 million crowns in 1921.

Most of the States in Central Europe have no definite statistics which would enable them to compare the present with the past situation. We may, however, draw attention to a few observations contained in the reports.

In the Serb-Croat-Slovene Kingdom, the financial situation of the railways is very serious; the receipts hardly cover half the working costs. The adoption of the eight-hour day in an agricultural country like Jugo-Slavia has not only led to a general rise in prices, but has created an almost paradoxical situation. There could be no better example of the absurd lengths to which the application of this principle may be carried than the fact that it is necessary to have three shifts working eight hours each on lines over which only two trains run in 24 hours!

The Roumanian report records the following disastrous financial facts: the deficit in 1920 was 330 millions, while before the war there was an annual surplus of receipts amounting to 40 millions.

In 1911 receipts from the Bulgarian system amounted to 27 million leva, and expenditure to 17 millions, giving a surplus of 10 millions. In 1920 receipts were 143 millions, as against an expenditure of 200 000 000 making a deficit of 57 million leva.

Standard-gauge railways in Greece within her former limits (we have no data with regard to the Macedonian lines) did not pay very well in 1914, and profits were still smaller in 1919. The co-efficient of operation rose from 93 % to 101 %. The deficit, which, when all the charges on capital were taken into account, amounted to 5 million drachmæ, rose to 10 millions.

Narrow-gauge railways, on the other hand, yielded, and still yield, a profit.

The railways in Finland also show a surplus.

Esthonia is looking forward to the immediate future with confidence.

Lithuania, which in 1913, apart from the charges on capital, realised a net profit of 11 million gold roubles, showed a deficit of 12 million German marks for 1920. This altered position is attributed to the political difficulties arising from the occupation of Southern Lithuania by Polish troops — the military occupation having impeded goods traffic — and to the scarcity of money for the purchase of rolling-stock.

* * *

In comparing these figures it must be remembered that the returns do not cover the same ground in different countries; certain countries, more particularly in reckoning the deficit, take into account — and this is the correct method — charges connected with capital; the others make no statement regarding either, and merely compare receipts with working costs for the period of a year. Whenever the terms of the reports enable us to do so we have stated whether the deficit included or excluded the interest on the capital employed; simi-

larly we mention the amount of the capital to which the annual profit or loss referred.

Moreover, when the documents which we had at our disposal permitted us to do so, we gave the statistics relating to the co-efficient of operation (the ratio between expenditure and income) — one of the best indications of the financial position of a railway system.

Heavy deficits are due primarily, as we have already pointed out, to the fact that tariffs were not raised in proportion to the increase in the cost of working expenses, as it was feared, and rightly so, that the result would be to raise the price of the necessaries of life; these deficits are also due to the disorganisation which has overtaken all administrations and which is shown in an all-round increase in the number of the staff. Confusion, indeed, leads to more work as well as to an undue increase in the number of employees. This increase is entirely out of proportion to the work which would be required of a staff under normal conditions.

But there were other still more noticeable causes, the eight-hour day, for example, which also led to an increase in the number of employees. While it is tolerable in all industries in which piece-work predominates, the eight-hour day became specially burdensome on the railways as a result of the difficulties which were experienced in reconciling the varied requirements of the service with the shorter day. It is not too much to state that for many classes of personnel the apparently slight reduction of the hours of labour has involved doubling the number of the staff, and it must be remembered that this happened at a time when wages were increasing much more rapidly than it was possible to raise tariffs without incurring the risk of reducing receipts.

The rise in the price of fuel has also considerably aggravated the financial position, but while the coal crisis may be regarded as over, the increase in expenditure under the heading of staff appears to be very difficult to arrest. Almost everywhere railway employees are regarded as entitled to security of employment and to wages increasing with length of service; these employees, moreover, are a united body, well organised and prone to go on strike — a fact which, taken in conjunction with the weakness of Governments struggling with the difficulties arising from the war, has introduced a political element into the question of the fixing of wages.

When we consider that the expenditure on staff in an organisation common to all European railways represents at the present time 70 to 80 % of the total working expenses, it will be easily understood how completely the restoration of railway finances is bound up with the question of the number and remuneration of the staff; but it is difficult to suggest a solution because the question is as much a political question as an economic one.

Such are the reasons which may be advanced in support of the opinions of critics who maintain that great efforts and much time will be required before a return can be made to former conditions in which railway receipts and expenditure balanced. It is possible to accept this view provided always that we differentiate between countries which suffered seriously from the war and those which were victorious or remained neutral.

It is perhaps unnecessary to add that this state of affairs will, in spite of the vast schemes which have been drawn up in every country, hamper the development of railways. Private capitalists will probably be averse to investing money in railways, and public funds which are subject to especially heavy demands in those countries where the need for new lines in greatest, will not be able to take the place of private enterprise.

In presence of all these difficulties it would be foolish to shut one's eyes to

the difficulties; the right course to adopt is to face them.

While all the chief European States complied with the request addressed to them, only a small number of States outside Europe replied to our questionnaire. Among these were eight American countries : Bolivia, Brazil, Canada, Chile, Guatemala, Haïti, Panama and Paraguay, and four Asiatic States : China, Japan, India and Persia, which sent in the required statistics.

In 1922 there were in America (according to the statistics contained in the *Archiv fur Eisenbahnwesen*) 344 323 miles of railway, but the countries which forwarded replies had only 46 688 miles of line — that is to say, a little more than 13 % of the whole.

North America was represented by Canada alone; Central America by the Republics of Haïti, Guatemala and Panama; South America by Bolivia, Brazil, Chile and Paraguay. We are thus not in a position to draw up a complete account of means of communication throughout the length and breadth of the American continent.

Moreover, while the reports supply interesting information, especially from the point of view of a description of the various systems, they clearly show that the war had no serious effects on the working of the railways.

Further, the particulars supplied refer to regional systems exploited by many companies according to various methods and under a system by which freedom of organisation and full liberty to fix the tariffs were allowed; we therefore do not possess the general statistical information which is necessary for bringing out clearly the characteristic features which we have noted in dealing with Europe.

Canada, in 1914, owned 30 789 miles of line and 38 888 miles in 1919. This is a rather remarkable increase, amounting to about 20 %, and shows that building was in no way checked by the war. Canada is a vast and sparsely populated country, and her railways have not arrived at that final state of development which has been reached in Europe; it is prosperous to a degree and can develop that prosperity still further by opening up new means of communication.

The great trans-continental lines in Canada, such as the Canadian National Railway, the Grand Trunk Railway, and the Canadian Pacific Railway are well known; they represent five-sixths of the whole system, the remaining sixth consisting of local lines.

The Canadian lines are of the European standard-gauge and can use the same rolling-stock as the adjacent lines in the United States.

We have no statistics on the volume of goods traffic and the financial position.

The Haitian Republic is rather densely populated in comparison with other American territories. The need for means of communication is therefore keenly felt. In 1915 there were 157 miles of narrow-gauge railway, all having their terminus at Port-au-Prince. No new lines have been laid since 1915, but we are unable to state whether this fact is to be attributed to the war.

In the Republic of Guatemala there are 685 miles of railway, and in the Republic of Panama rather more than 311 miles.

Brazil owns 17 478 miles of line, the larger portion of which — 15 599 — is one-metre (3 ft. 3 3/8 in.) gauge. The report calls attention to the fact that the construction of a system of this importance is a remarkable achievement for a country like Brazil.

It has to import from abroad both rails and rolling-stock; labour is scarce and therefore dear; further, the difficulties presented by the ground are great and varied. The population, again, is grouped into a few widely scattered centres, since Brazil has only 30 million inhabitants on a territory as large as Europe.

It will be necessary to lay new lines to link up some of the existing systems

which are at the present time unconnected.

In Bolivia 325 miles of railway are in operation and 417 miles under construction.

At present Chile owns 5 592 miles of railway, as against 3 958 in 1912. Moreover 6 214 miles of new line are in contemplation.

The capital invested in railways is 700 million gold francs; in 1918 receipts were 123 million gold francs; the figures for traffic are 27 million for passengers and 16 million tons for goods. Coal is obtained from the national mines.

Paraguay has few railway lines (in 1912 there were only 232 miles), but new and important lines are in contemplation. It should be noted that this country has many large navigable rivers which supply it with means of communication throughout its whole extent.

Still quoting the statistics contained in the *Archiv fur Eisenbahnwesen*, we are able to state that Asia had in 1912 66 631 miles of line, and the countries which replied to the questionnaire (China, Japan, Persia, British Indies) had, at this date, railway systems amounting to 46 461 miles, that is to say about 70 % of the whole. Their reports enable us, therefore, to form an idea of the importance of the Asiatic railway systems, since, apart from Asiatic Russia, for which we have no statistics relating to the war period, those railways are all in China, Japan and India.

In China there were 6 784 miles of lines in operation, 2 220 miles under construction and 14 174 miles which were being planned or for which concessions had already been granted. In 1915 China had 629 locomotives; the number rose to 653 in 1918. The volume of traffic, which was 12 735 015 train-miles in 1915, amounted to 14 539 256 train-miles in 1918. The number of passengers increased during the same period from 20 043 209 to 25 740 841, and goods traffic from 32 473 043 to 44 490 538 tons. The consumption of coal was 504 285 tons in 1915, and 631 313 tons in 1918. The price of this coal rose from 6.72 to 7.86 Chinese dollars.

We possess no further information, but we have every reason for believing that the effects of the world-war on Chinese railways were of small importance.

Japan, on the contrary, experienced the effects of the war, in which from the very outset she took an active part, especially on the industrial side.

The necessity for opening up communications by land with her allies gave a great impetus to traffic through Russia. It should be added that Japan has always been deeply interested in the question of direct communication with Europe by rail. For this reason she was a party to the Berne Convention, and she inaugurated passenger and freight services between the Japanese and Korean railways and the Chinese and Russian railways. Among the various direct passenger services, mention may be made of the two great routes known as the « Circular route *via* Siberia and Suez » and the « Route round the world *via* Siberia and Canada ».

In 1914 the Japanese railways were largely operated by the State and were of a total length of 6 568 miles. The Government, following a prepared plan, annually laid about 218 miles of new line. During the war, however, it was impossible to carry out the work on the full scale demanded by the plan, but in 1919 the length of the system was 8 217 miles.

Rolling-stock increased during the war, the number of locomotives rose from 2 500 to 3 101, passenger coaches from 6 440 to 7 250 and goods trucks from 42 614 to 51 065. During the years immediately preceding the war, railway transport was passing through a period of serious depression; but in 1915 an area of unprecedented prosperity opened for Japanese industry and commerce and this lasted down to the armistice. Passenger traffic at this time showed an

increase of 119 %, and goods traffic an increase of 11 %. Passenger rates had to be raised from July 1918 by 25 % for third class, 75 % for second class and 117 % for first class. A further increase, which involved an additional 20, 30 and 40 % for the three classes respectively, followed these earlier measures. Freight rates were raised 20 % in 1918 and again increased in 1920 by 28 %. The consumption of fuel on the Japanese railways rose from 1 700 000 tons in 1914 to 3 070 000 tons in 1919 — an increase of 72.5 %, which was accompanied by a 40 % rise in prices.

The financial results proved satisfactory even during the period when the effects of the war were most acutely felt. In 1914 the net return on the capital invested (1 007 000 yen) was 5 %; it rose to 7 % in 1919. After the armistice a period of depression set in.

Owing to her distance from the theatre of war, Japan, while suffering no injury directly due to hostilities, benefited by the increased activity arising from the war.

British India also felt the effect of the war and experienced some of the characteristic difficulties directly caused thereby, such as shortage of stock and labour and the attendant delays in carrying out repairs.

During the war the Indian railways supplied Mesopotamia and other theatres of war with a number of locomotives and much rolling-stock. Indian workshops were employed in the manufacture of ammunition, and the result is a shortage of stock for present requirements. But the railway administration acted prudently, for it at once began to secure supplies of the necessary stock, the purchase of which involved a very heavy outlay in 1920.

Passenger and goods rates were slightly increased; the consumption and price of fuel rose. The coal in use is chiefly of native origin.

India has about 31 000 miles of line. Traffic developed largely during the war (it rose from 16 156 000 passenger-miles in 1914 to 19 884 000 in 1920; from 14 066 070 English ton-miles of goods in 1914 to 19 570 185 in 1920).

Persia is poorly provided with railways (the existing lines do not greatly exceed 155 miles, but the present Government intends to encourage the growth of railways. It is considering new lines and is investigating plans which have been submitted by private companies desiring concessions.

[621. 33 (.44)]

Report on the Opening of the Pau-Lourdes line by electric traction,

By E. UYTBORCK,
HONORARY ENGINEER OF THE BELGIAN STATE RAILWAYS.

At 9 a. m. on Monday 30 October 1922 an electric locomotive hauled a passenger train consisting of five bogie coaches and carrying the guests for the ceremony over the Pau-Lourdes line. The opening of this section of the line marks the first step taken by the Midi railway towards the ultimate electrification of the whole of its southern lines, in accordance with the Government scheme.

It will be remembered that, as far back as 1913, this Company made trials of electric traction by monophase current, in particular between Vernet-les-Bains and Bourg-Madame; in the present instance, which conforms to the new scheme, the company is using continuous current at 1 500 volts.

The Limited Company styled « Les Constructions électriques de France », which was entrusted with the building of the new electric locomotives, desired to give the opening ceremony as much éclat as possible.

About 160 people were invited : M. Le Troquer, Minister of Public Works, the Military and Civil authorities, the Members of the boards of « Les Constructions électriques de France » and of « Les Exploitations électriques » amongst whom, it will be remembered, are a number of Belgians of high position, the high officials of the French railways and of the Belgian State railways and particularly those interested in electric traction, professors from the Universities, and press representatives. All had hastened to accept the invitation of « Les Constructions électriques de France ».

The guests were first shown successively the two substations which transform the three-phase alternating 60 000-volt current into continuous current at 1 500 volts for direct supply to the motor vehicles.

The first substation comprises an open-air transformer installation, and in a neighbouring building a group of rotary transformers fitted with the latest improvements.

The second substation situated actually in Lourdes, which was originally equipped for transforming the 60 000-volt current into 10 000-volt single-phase, has only a set of mercury converters the working of which proved of great interest to the visitors.

The Midi Company, by equipping its two substations in different ways have done so with the object of ascertaining the relative advantages of the two systems as well as the possibility of running the two substations in parallel. The latter point has been settled and no difficulty has arisen in putting these two substations in parallel through the overhead conductors.

The Tarbes works of « Les Constructions électriques de France » were next visited.

It is barely two years since work was commenced on a site having an area of 79 acres; the main shops are of concrete

throughout and fitted with the latest devices and plant. The first two hundred electric locomotives for working the line between Dax and Toulouse are being built here. Two passenger locomotives fitted with motors having their axes vertical will shortly be under test. At a later period automotor vehicles will be built here as well as the electric equipment for the hydro-electric generating stations intended for utilizing the water power from the mountain chain of the Pyrenees. The visitors admired the excellent arrangement of the shops and were able to appreciate that all precautions had been taken to ensure that the work would be done under the most favourable modern conditions for production and for health. The normal working day is nine hours.

Workmen's dwellings have been built in the vicinity. The management has decided to make special terms for workmen who wish to cultivate allotments for their domestic requirements; they will be afforded facilities at harvest and sowing times, provided that they make up the time at those periods of the year when the demands of agriculture are small.

The visitors were invited to a dinner in one of the workshops and several speeches were made; that made by the Minister of Public Works was of particular interest to those present, because it expressed the absolute confidence that the French Government had in the future of electric traction in France; the Minister foresaw the extension of electric traction to lines for which its use had not yet been contemplated, on account of the much greater safety it affords for working passenger traffic.

The overhead conductor is arranged on the catenary system recently used on the Philadelphia-Paoli line which enables the current to be taken without any visible sparking; this is ensured by the arrangement of two pantograph bows on each locomotive each fitted with two rubbing pieces. The locomotives are carried on two bogies coupled in a special manner and each fitted with two motors capable of exerting 250 kw. for one hour. The connections of the motors are of the usual series-parallel type. In the drivers' cabs there are in addition to the contactors, resistances, etc., a 1 500-volt motor running a 110-volt continuous current dynamo for the auxiliary plant on the locomotive, such as, the current for the contactor relays, for running the air-brake compressor, etc., and also a variable voltage dynamo for use in recuperating power in braking.

It has been decided that some of the locomotives of this type will not be fitted with recuperating appliances.

At the trials of the locomotive, the experts were highly satisfied with its great stability, the ease with which it was controlled, its easy running on to curves and the excellent arrangement of the cab in which are grouped the various accessories for controlling the motors and applying the brakes.

RAILWAY LOCATION,

By SIDNEY BLENCOWE,
ASSOC. M. INST. C. E.

Figs. 1 to 4, pp. 50 to 67.

(*Minutes of Proceedings of the Institution of Civil Engineers.*)

The purpose of this paper is to describe and recommend a system for carrying out railway location work.

In deciding what the strength of a survey or locating party should be — a point on which much difference of opinion exists — there are three main elements to be considered, namely :

a) Whether the route to be located is over flat, undulating, or mountainous country;

b) Whether the progress of the work is to be hurried, or to be proceeded with normally;

c) Whether the party is permanently or indefinitely in commission or not.

It has been the experience of the Author that, from the time authority is given to commence work, rapid progress is urged from headquarters. A chief of party will, therefore, be well advised to obtain a reasonably strong party of assistants, as, if the party is well handled, a saving of time must result.

The basis of a scheme of railway extension is the work of the locating party; an inefficient unit not only takes considerably longer over that work, but may be, and generally is, a means of wasting many thousand pounds. The work, however, should not be unduly hurried from headquarters as, frequently, an extra £50 spent on location will save £1 000 on construction and often a permanent charge on maintenance and running.

Five is an economical number of assistants for ordinary work of lengthy duration, although this number might be reduced should the zone of a proposed extension be flat and heavily wooded; on the other hand, if a study of alternative routes is essential it may be increased with advantage.

Of the five, the first three should be trained and experienced men, and the other two, although they need not possess such comprehensive knowledge, should, at least, be able to take charge of any instrument should necessity arise.

In the author's experience, a location party's personnel is generally drawn from various engineering fields, such as constructional, and permanent-way men, draughtsmen, and quantity surveyors, some of whom are on railway location work for the first time. Such being the case, the chief of the party will do well to spend two or three days at his base of operations in finding out the qualifications of his assistants, and incidentally in training his labourers or « peones » in chaining, holding staves, giving double points for the transit, etc. He will find that mistakes of many kinds occur within the first few weeks if the party is new to the work, and that a couple of days thus spent are well invested, as it is useless to attempt to accelerate progress until individuals become familiar with one another's duties. If the chief is in the happy position of being able to select assistants, he should, if possible, choose those who possess amongst them a knowledge of the following additional subjects : Photography, geology, mineralogy, chemistry, agriculture, meteorology, elementary astronomy, and well-bor-

ing. A knowledge of army signalling will save much horseflesh and time. All assistants should be able to ride and walk well, be sound in health, active, and able to swim.

Before leaving the headquarters of the railway, the chief of party must obtain from the chief engineer the general object and route of the proposed extension, the ruling curvature and gradient, the limiting radius of untransitioned curves, and his suggestions on maximum cuts and banks. The chief must bear in mind that any deviation may result in increased working-expenses with possibly the risk of commercial failure, especially should the proposed new route be a competitive one.

The chief will find out what types of bridges and culverts are in vogue, the class of track, turn-outs, and the standard plan of station-yards. He should obtain such plans of the district as may be in existence, together with information concerning it; also the latitude and longitude of the proposed point of « take off » (which should be checked upon the ground), the reduced rail-level of that point and a profile of existing track in the vicinity. He should then proceed to carry out the reconnaissance, taking with him for preference his second assistant, leaving his first with instructions to arrange the details of fitting out the party.

The operations of locating a proposed railway may be divided into four steps :

1° Reconnaissance or exploration;
2° Preliminary line or lines;
3° Trial location or locations;
4° Final locations.

(1) *Reconnaissance.* — The method of carrying this out will depend on *a*) the amount of knowledge possessed of the district to be opened up to railway communication; *b*) the configuration of the country. The most difficult country to study is that which may be described as undulating, where optical illusions occur, and an easier gradient is expected than will eventually be obtained.

Alternative routes will present themselves, and, unless the chief of party can satisfy himself by the aid of hand instruments which is best, he will be compelled to locate preliminary lines; should the country be wooded, his difficulties are considerably increased, whereas in mountainous configuration his attention is almost wholly confined to valleys of suitable orientation, and in flat country to the avoidance of areas liable to floods.

Should the district be comparatively unknown, trouble and delay will be saved if the bearing of the proposed railway route is chosen to form the approximate course of reconnaissance for the distance to be penetrated. This baseline should then be followed with the sketch-board from eminence to eminence, distances being estimated by the pace of the horse (all reconnaissances should be carried out at a walking pace). At every eminence bearings should be taken on to all outstanding physical features, and lateral detours should be made in order to sketch in the salient topography, with remarks as to soil, vegetation, etc. Barometrical readings, with the shade temperatures of the intermediate air, should be observed periodically, and at all crowns and depressions, for the purpose of constructing a profile of the line followed.

The chief will find it advantageous to keep his assistant on the objective bearing, whilst he deviates to both right and left, this system being continued until the distance of the proposed extension has been covered. Each evening the barometrical altitude should be checked with a hypsometrical reading, for the aneroid is unreliable if long intervals of time elapse between observations. The Author recommends that, in addition to the two aneroids in use, a third should be carried for the purpose of a check, also that a careful man should be left at the railway take-off (*i. e.*, at the known

reduced level), with one or three aneroids whose readings should be recorded every hour between sunrise and sunset, together with notes as to wind, clouds temperature; this will be for subsequent comparison with those of the reconnaissance party, to reduce the meteorological oscillation to a fixed level.

On the return journey the party should be divided, the chief and his assistant returning by courses parallel to the outward route, a few miles to the right and left of it respectively, again recording the physical features of the country by compass and aneroid, and never failing to observe any visible points that were recorded when on the outward journey. On the return to the starting-point, sufficient information should have been collected to enable a report on the reconnaissance to be written that will recommend a route or routes to be studied by preliminary lines, and at the same time give an idea whether the prospects are favourable for the ruling gradient; the class of country traversed; its geological formation, rivers and streams to be crossed; with descriptions, traffic prospects and an approximate estimate of the length and cost of the proposed extension.

If a reconnaissance has to be carried out in mountainous country, chief attention must be paid to valleys with suitable orientation, noting narrow partitions between valleys with geological faults in places where tunnelling might be necessary. Wherever possible, the route of perambulation should be along the higher altitudes so that the greatest advantage may be taken of opportunities of viewing the configuration; bottoms of depressions and valleys should, however, be visited from time to time.

In extensive flat country special regard must be paid to dry lagoons and areas liable to flood, as it must be remembered that in some climates long droughts occur, and the unpractised eye may fail to observe large areas which in wet seasons will become sheets of water with sluggish currents.

Railway banks intersecting such country will eventually suffer disaster if sufficient openings are not allowed, and the floodwater on the up-side is likely to be impounded, accelerating the velocities at the openings. The Author's experience is that in such cases it is not the weight of the impounded water that causes the banks to give way, but wave-action due to wind, or scour on the lower side of the bank, caused by water overflowing the rails. The experienced locating engineer will know the higher lands from the slight difference in colour of the pasture, by the class of vegetation, and possibly by the remains or marks of a previous flood; but he will be wise to seek information on this and other points from the older inhabitants of the district. In cultivated and closely-fenced country the most advantageous intersection of properties must be considered in sympathy with proprietors, whose claims must be respected.

In the interests of economy, a chief of party must keep the fieldwork continually in progress. The practice of carrying out fieldwork in the forenoon, and the plotting and calculations in the afternoon, is to be deprecated. The Author is of opinion that the practice of keeping an able assistant — not merely a draughtsman — continually occupied in the drawing-tent, where, if an intelligent and quick man, he will cope with the whole of the plotting of the field-work, and, in addition, will assist his chief in calculations and projections, is the better and more economical arrangement. Each assistant should be responsible for the correct adjustment of his instruments. It is not sufficient to adjust for collimation alone; the plane of rotation, horizontal bar, line of sight, and bubble-tubes must be corrected. A little reflection on working conditions in unknown country will emphasize this necessity. Aneroids and prismatic com-

passes should have their index errors noted before use, and chains, steel bands, tapes and staves should be tested before leaving headquarters.

The designation of assistants in order of seniority is advisable, as, when various sections of a field-party are working in combination, such incidents as the tacheometer or levels overrunning the transit, the check leveller overrunning the leveller, and so on, cause confusion and friction between individuals and interfere with the progress of the work; further, should an engineer be absent, the question of the discipline of the party is automatically solved. An engineer when delayed should employ himself in reducing his fieldbook; levellers especially, who suffer from delays, should avail themselves of such opportunities in order to determine the gradient in case it should be urgently required. Each assistant must reduce his fieldbook before handing it in at the office tent, and the reductions, which for an expert man should not take more than 1/2 hour, when not already done, ought to be completed during the evening. The practice of persuading the office assistant to effect the reductions is reprehensible.

The first assistant or transitman is responsible for the fieldparty leaving the encampment punctually in the morning, but he is not responsible for the equipment of other assistants. A good working system is for a list of the technical equipment required to be given to the ganger overnight, although this practice should not relieve each assistant of his individual responsibility.

The transitman should determine the luncheon place, inform his chief, and give the necessary instructions to the quartermaster.

(2) *Preliminary lines.* — These are most advantageously carried out with the transit instrument in conjunction with the tacheometer. The degree of accuracy required for both distances and altitudes is well within the capabilities of these instruments and should not exceed 0.20 metre vertical and 10 metres horizontal per kilometre. A high degree of accuracy involves a sacrifice of speed, and is unnecessary for preliminary work.

This error may be doubled without materially affecting the projection for a trial location. The saving in labour, as compared with the system of theodolite and chain, with cross sections, is more real than apparent.

In the first case the following strength is needed (table II):

Transitman;	Peg and spademan;
Tacheometrist;	6 rodmen;
2 flagmen;	2 orderlies;

as compared with :

Transitman;	Peg and spademan;
2 levellers;	Topographer;
2 chainers;	4 rodmen;
2 flagmen;	2 orderlies.

which means a saving of one engineer and one labourer in favour of the tacheometrical method, the outstanding advantage being the rate of progress, which is increased by between 50 and 100 %.

The office-work resulting from the use of the tacheometer is more laborious than that of the level-book, which balances and checks itself; but the Author has introduced a graphic table from which the reduced level may be pricked off from the angle of elevation or depression, and the difference of the hairs (figs. 3 and 4), thus entirely dispensing with the use of Jordan's or similar tables.

The tacheometer is not designed for a high degree of accuracy, and a matter of 0.05 metre in altitude on a preliminary line, and a similar amount in the reduction of the reduced level of intermediate observations, the error of which is non-accumulative, is of no account in prac-

tice. The change-points (fig. 1), however, should be observed both ways in the field and should be reduced accurately. All tacheometrical reductions should be checked, as, in reading off the tables, it is as easy to make a mistake of 5 metres as of 1 centimetre.

The engineer who is not conversant with the tacheometer is likely to disapprove of its employment; but, having once used it, he will not care to return to the system of cross sectioning.

If the tacheometer is not adopted, the survey of preliminary lines through country where the gradient is assured resolves itself into tracing the line with the transit, and cross sectioning on either side with levels. In heavy country the transit will set the ruling gradient; but, should the changes of direction be great, allowance will need to be made for compensation for curvature, and the transit must reduce its angle of gradient accordingly; otherwise, it will be found that the projection for the ruling gradient on the trial location will not fall or rise sufficiently to be contained within the zone of cross sections, and the work will consequently be wasted.

Reference to figure 1 will give an idea for carrying out a preliminary line on the tacheometrical system, and it will be noticed that mounted flank topographers are introduced in order to cover a belt 3 kilometres in width in open country : this will almost invariably result in the supply of sufficient data for the projection of a trial location.

The system described has the merit that one preliminary line is generally found to be sufficient, that an advantageous deviation from the centre-line is anticipated, and that the resulting trial location will, in all probability, remain as, or be approximately, the final location.

The progress of preliminary lines with an efficient party in open country should be not less than 5 kilometres per day. Each engineer should have two field-books, for alternate use, one of which will be in use and the other in the office at the encampment, in order that plotting may go forward with field-work.

The plotted field-books must be obtained from the office before unplotted ones are sent in, to ensure that, in case of delay to the messenger, the use of scraps of paper containing data is avoided.

When preliminary lines have to be carried over flat country to a fixed point, such as a bridge-site or railway-connection, and especially if heavy brushwood or forest intervenes, it is a satisfactory practice to send forward an assistant with three to six rockets, which should be fired at night at a prearranged time, when the bearing will be observed by the transit-man. This method is reliable for about 12 miles on equal altitudes, but with rising ground for the objective it may be adopted up to any reasonable distance provided the rise more than compensates the earth's curvature.

Individual duties on preliminary lines (fig. 1). — The chief of party indicates the route.

The first assistant, or transit-man, who is in charge of the field-party, traverses the course indicated, keeping his change-points at intervals of approximately 500 metres. He numbers these points in sequence A^1, A^2, A^3 and so on. At the index letter A of this particular preliminary line, he drives a light wooden stake and marks it with red pencil. He instructs his front flagman to plant ranging poles at these points, carrying red, white and black bunting alternately, so that the flank topographers, described later, may be enabled to take prismatic compass observations with no risk of mistake. In addition to the work of tracing the centre-line and recording the topography in the vinicity, with estimated distances, he should take observations of all salient points, in order to relieve the tacheome-

trist of any work beyond that of recording data for the projection of profiles.

The second assistant remains at the encampment and plots the field-work as it progresses. It is his duty to reduce the tacheometrical observations and re-

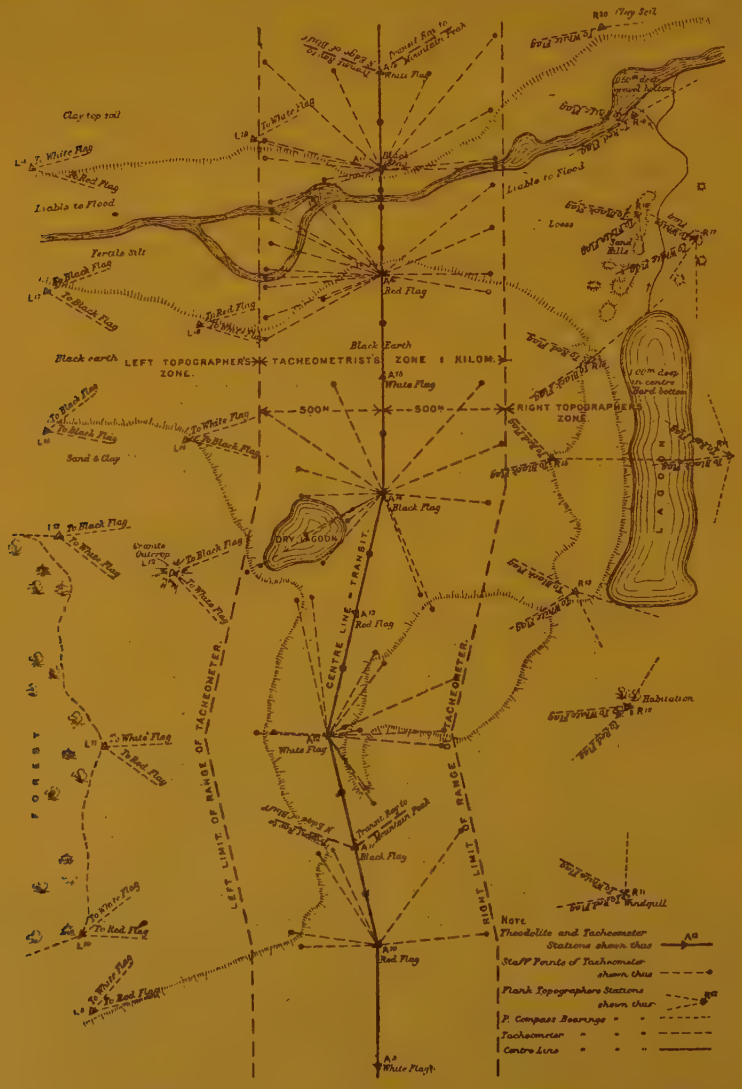


Fig. 1. — Railway Location, Preliminary Line. Example of Field-Work.

vise the level-books, which should be initialled by him as correct, as should also each page, when once the contents have been plotted. He is responsible for the record of meteorological observations, morning, noon, and night, and is in charge of all work pertaining to the office.

The third assistant carries out the tacheometrical observations. His base points will have been determined by the transit-man. He should keep two of his rodmen always on the centre-line for the backward and forward readings of base distances, and his remaining four men should be divided, two on each side of the centre-line. The radius of observations, with staves graduated to 10 centimetre divisions, extends to 500 metres. It will be observed from figure 1 that detail observations are taken at every other station only, *i. e.*, A^{10}, A^{12}, A^{14}, etc., the intermediate ones being change-points through which to carry on the tacheometrical levels and distances.

The duties of the fourth and fifth assistants are identical, one taking the right-hand side of the centre-line and the other the left. Each should keep about 1 kilometre from it when range of vision allows, and should record with prismatic compass and aneroid barometer all topography of importance contained within a belt of land 1 kilometre in width his course intersects. The inside limit of each zone will, therefore, abut on that of the tacheometrist. The temperature of the intermediate air should accompany all aneroid observations in order to make the necessary correction when reducing for altitude.

The station-points have been flagged (as mentioned above) so that these topographers may observe them from convenient hillocks, or other points of vantage, within their respective zones. The index error of both prismatic compass and aneroid, as compared with the centre-line, should be distinctly marked in red in the topographers' field-books. Reference to figure 1 will elucidate their mode of procedure, progress, and co-ordination with the tacheometrist.

(3) *Trial location.* — A trial location is the tracing, on the ground, of a projection which results from a preliminary line.

The preliminary work having been plotted to a scale sufficiently large to interpolate contours of 1 metre altitude, a *paper* location is projected, either directly on to the squared paper plan or, to save confusion of lines, on a covering tracing-paper. Experts will probably prefer to lay their projection directly on the original plan, but the less experienced will do well to project on tracing-paper. The chief of party will often be able to leave the field-party for half a day, having previously determined points ahead of the transit to keep the party employed, when he must carry out this work of projecting the trial location. He will find that his first projection can be best traced on the plan by setting the dividers to some convenient distance, say 100 metres; then, if his ruling gradient is 1 : 100 or 1 % he should intersect the metre contours with the distance contained by the dividers, making any necessary allowance for compensation where curvature has to be introduced. The Author has compiled a table for these allowances in order that the equivalent, according to the rate of compensation (or degree of curvature in American practice), may be projected without the hindrance of working each one out separately as it occurs (table VII).

When the initial projection has been completed in the foregoing manner, the profile should be plotted from the contours, which will demonstrate the cuts and banks; and his work will then be to reduce these to a minimum, allowing the banks to exceed the cuts in the ratio of 5 to 3. If these earthworks remain too formidable he must attempt further projections on the data supplied, until he obtains a satisfactory profile, failing which, he must try other preliminary lines; and, if there is no prospect of obtaining an improved profile, he has perforce to obtain a reduction in the ruling gradient and perhaps in the curvature. It is well to emphasize that the latter must be adopted to suit the speed requi-

rements and the fixed wheel-base of the rolling stock, and it is safe policy to give as large a radius as possible in the minimum curve at the expense of an increase in embankment. The minimum straight between reverse curves should be sufficient to run off the superelevation, plus twice the length of the longest carriage.

In setting out curves, the Author has found that a considerable saving of time results if the detail is prepared in the office, arranging the first full tangential angle of the chord to correspond to 360° on the vernier.

A satisfactory paper trial location having been obtained, it is traced on the ground by means of the transit (theodolite), level, and check level, only using pegs for instrument points and intersection points BC, CC and EC (beginning, centre and end) of curves. Each hundred metres of the chainage should be marked by a spit of earth and each kilometre by four spits of earth. It is convenient to add a spit of earth on either side of an instrument point.

The field-party is made up by the third or tacheometrical assistant becoming topographer to the transit, whilst the two flank topographers of the preliminary lines become leveller and check leveller respectively (table III). The chief of party should be in rear of the trial location, in order to see how his paper location reveals itself on the ground; he should especially note points of maximum cut and bank, river- and stream-crossings, proposed culverts, with detailed information to assist in the calculation of spans and headway, station-sites, level-crossings, etc.

Excavation should be made at the points of greatest cuts to at least their depths, also at proposed station-sites, recording the soils in each case.

The plotted trial location should coincide approximately with the paper profile from which it is derived. Minor improvements may suggest themselves in the tracing of the centre-line, and, if confirmed, should be adopted in the final location.

(4) *Final location.* — The final location should be carried out on the principle of the trial location, except that a high degree of accuracy is to be observed. It should be commenced from the existing railway with zero at the tangent-point, or BC of the turnout curve. All tangent points, *i. e.*, BC and EC, of curves should be staked on the ground with three hardwood pegs, a nail on the centre peg corresponding with the centre-line of the location. These pegs should be 40 × 5 × 5 centimetres. The intersection-point of curves should be staked by five similar pegs, a nail marking the point of deflection on the centre one. The stake at each 100 metres should be 35 × 4 × 4 centimetres, and may be of pitch-pine. Each kilometre peg and bench-mark peg at, say 10 metres from the centre-line should be of hardwood and of the larger scantling. Each hectometre should carry its initial figure on a zinc plate nailed to the peg, and each kilometre peg its number in full in a similar manner. In addition, each 100 metres and instrument point should have a decided spit of earth turned up on each side of the peg; and each kilometre two spits on each side. These spits enable the line to be picked up at any time during later months, but it must be remembered that, in most countries, after a year has elapsed the peg will probably be overgrown and the spit will have disappeared. The void, however, from which the spit was formed, will remain much longer in evidence.

The trial location should coincide with the final location for the greater part of its length. In wooded country the advantage of having a trial location based on a well-studied preliminary will result in the saving of much axe-work.

Topographer and levellers are employed as in the trial location. The former keeps the field-book and should measure

accurately all topography within 150 metres of the centre-line; outside of that distance he need not concern himself, as for small scale plans there should be sufficient information in the data obtained on the preliminary and trial locations. The error between the leveller's and check leveller's results should not exceed 0.03 metre and on no account must this difference be reduced to a mean : their respective level collimations must continue throughout the length of the proposed extension without exceeding this error. It is a good rule that, when this difference is exceeded, the check leveller should go back to the last peg within the limit, and thence onward, the one who was in error should be the one to return and relevel when next an excessive difference occurs. Each peg, and not every other peg, is to be checked. Reading off the same staff by leveller and check leveller must be prohibited.

Each assistant of the party should record his opinion of proposed bridge- and culvert-openings in the margin of his field-book.

Throughout location the leveller should confine his attention to the centre-line, and, in addition to the 100-metre pegs, he must observe all crown-, bed- and flood-levels. The chek leveller, in addition to carrying out the check, should take a short cross section at each kilometre and, on sides of hills, spot levels at 100 metres from the centre-line both up and down all watercourses, giving the bed, water, bank and maximum flood-levels. With regard to the system of levelling to be adopted, the Author is in favour of the Rise and Fall method as compared with that of the Height of Instrument, as in the latter the field-book may be reduced without exposing a possible mistake in the reduction of the intermediate levels.

The top soil must be frequently examined for the presence of salts, to guide the engineer in deciding between steel or hardwood sleepers when earth ballast is contemplated; bushes of various kinds peculiar to salt districts will assist the locating engineer in this.

On completion of the field-work the chief should review all field-books and initial them; the work should then be plotted and the proposed line graded. On steep gradients, such as mountain or quarry lines, vertical curves should be introduced at changes of gradient.

When it is the duty of the locating party to prepare working-drawings, the chief must make himself conversant with the laws of the country as regards preparation of plans. When the plans are completed he should write a general report on the whole of the work, omitting no information that may be of use and interest. A synopsis of the knowledge and opinions expressed can be made should the document be too ponderous, whereas a restricted report cannot be amplified except by its author.

The efficient administration of the Transport and Commissariat is a factor all-important to success, and it should be in charge of a quartermaster responsible to the senior engineer for this duty and for camping arrangements.

Soundings. — Soundings are required for various purposes, and, although they are within the duties of the railway locating engineer, they pertain equally to those of maintenance and constructing engineers. They are indispensable for the location, design, and construction of moles, sewage-outfalls, piers, and breakwaters with their access channels, and from time to time, when the works have been executed, as a record of the presence or change of subaqueous silt and scour.

In rivers of capricious floods and currents, where the banks are low and of sandy formation, it is necessary to sound at least 1 kilometre above a proposed railway crossing, noting the currents and velocities, with their direction, and the water-levels on each day that soundings

are carried out. In rivers such as the Tamar, at the Great Western Railway bridge at Saltash, and the river Neuquen at the bridge of the Buenos Aires Great Southern Railway, levels may differ considerably from one bank to the other, and the discrepancies may vary at different heights of the river, especially if it be one affected by tides. The engineer, therefore must be careful not to accept water-levels on one side of a river only for reducing the altitudes of his soundings. It is advisable to enclose the area of water under consideration in a levelled polygon driving a peg at each vertex, from which the water-level may be recorded at any time.

The procedure in carrying out soundings varies according to the river or harbour to be sounded and the staff and means available. On railway reconnaissance work, the engineer will probably be able to record only rough depths and information. In unknown country, if no boat is available, he may have to rely on swimming and diving for his preliminary information; the results will enable him to decide what equipment will be necessary (table VI).

If a river is fordable in all parts, the shallow soundings may be observed advantageously by tacheometry, but if not, a boat is essential, with a sounding party made up as follows :

No. 1 or double oarsman;
No. 2. or sounder;
No. 3. or recorder to sounder;
No. 4 or flagman and relief oarsman.

The chief of the party should be in the boat, in order to direct the course and positions of the soundings.

On shore, trigonometrical points which command the field of view need to be selected along the river-bank or edge of the harbour, at intervals of about 300 metres, and may be either the vertices of, or connected to, the polygon introduced for the purpose of water-levels, each point being lettered in sequence S^1, S^2, S^3, etc. (fig. 2). Two assistants with theodolites are necessary, at stations which should be near to one another, each with the vernier clamped at its accumulated bearing, for facility when plotting, and aligned on the neighbouring point. The upper plates are then released in order to follow the course of the boat and to determine the position of each sounding by intersection. The depth of soundings should be measured with a pole or line. In rivers, especially with swift currents, the former is the more reliable, but in harbours, owing to the greater depths, the latter will have to be employed. Both must be graduated in the measure to which the soundings have to be reduced (sea work is generally in feet or fathoms, and railway work in foreign countries in metres), in order that the depths may be read off clearly and quickly.

The bottom of the sounding-pole or line should be encased in, or attached to, a lead shoe which is concave on its under side, the cavity being filled with grease, so that a sample of the river-bed may be obtained for analysis. The soundings should be taken at sufficiently long intervals that the assistants at the theodolites may have time to align the ray, read the vernier, record the observation, and return to the ready.

On being ordered to sound, No. 2 will let out the pole or line with alacrity and, as soon as it attains a vertical position, call out the depth, which No. 3 will record. No. 3 should also keep his eye on the pole or line, to check No. 2. On sounding, No. 4, who should be seated next to and on the up-stream side of No. 2, raises his flag, a ranging pole with bunting attached, to a vertical position, thereby providing a definite objective point for the two theodolites on the shore. Having allowed sufficient time for the instrumental observation, the flag is lowered until the next sounding is taken.

No. 1 should follow the course in such

a manner that the bow of the boat is kept as much up-stream as is compatible with progress (the slower the movement, within reason, in the required direction, the better), and thus nullify the effect of the current.

It is a good plan to record the soundings in groups of five corresponding with the observations of the engineers at the land stations : thus, at each termination, a prearranged signal is made and must be answered by the orderly in attendance at the respective instruments.

The positions of small islands and sandbanks may be determined by No. 4 landing and holding his flag at water-level at a number of points to be indicated by the chief of party, the engineers on land recording the positions.

The water-level of the river or tide must be recorded at a known point within each series of soundings in order to calculate the reduced levels. In tidal work this must be done every ten min-

Fig. 2. — Example of Soundings taken by Railway Location Party.

utes while soundings are being carried out, but on rivers it will generally be found sufficient to observe the water-level at the commencement and at the conclusion of the day's work (fig. 2).

Current-velocities must be recorded on all important stretches, and it must be remembered that a surface or float velocity has to be multiplied by a coefficient usually about 0.8, to obtain the mean velocity of the stream. These velocities will serve as a basis on which to calculate discharges, and the engineer will find it interesting to verify the value of *n*, the coefficient of roughness in Kutter's formula, from data at his disposal; it will assist him in determining the discharge at maximum-flood level.

Marine sounding, where river-currents have not to be contended with, may be

satisfactorily carried out by substituting beacons or ranging-poles of distinctive colours, and by observing two subtended angles at the boat or raft by sextant, arriving at the solution on the three-point principle.

The chief of party must be careful in the case of rivers to navigate the boat so that the rays by the theodolites do not form ill-conditioned intersection angles; this also applies to the subtended angle in the case of the sextant in marine work. A flat-bottomed boat will be found best for river work, and one with a keel, with a larger number of oarsmen, for marine work.

River-soundings should be taken during the months of low water, *i. e.*, when the current is at its weakest. The locating engineer should therefore obtain, at the Meteorological or Ways and Works Offices of the country, information on this head.

Should a steam or naphtha launch be available, the soundings are carried out in a similar manner, with the exception that No. 1 is displaced by a mechanic, and the duty of No. 4 is entirely manipulation of the flag.

The soundings are subsequently reduced to a common datum, making due allowance in their reduction for the fall of the river, and are plotted with a sufficient degree of accuracy by the use of a protractor. To attempt to determine the position of each point by trigonometrical formulas is unwarranted, seeing that the allowable horizontal or position error is about a metre. Should a sounding be required at any particular point, the boat must be anchored for the observation and its position ascertained trigonometrically. When once the soundings have been converted into altitudes in relation to a known datum, they are plotted and the contours are interpolated and recorded by proportion between each pair of levels. These contours should be at such altitudes as will suit the purposes of the work, generally 0.50 metre, and it is an advantage to colour the intervening space between contours with distinctive tints to emphasize siltings and scourings, especially for comparison with a plan of the same site executed at a previous date.

When soundings are at, or near, the zero or datum of the district, it is often desirable to add a round figure to the readings to eliminate negative reduced levels.

Bridge sites. — The selection of a railway-bridge site for a river-crossing is an important, if not the most important, problem in location work. In the first instance, *i. e.*, on reconnaissance, the river should be perambulated throughout that part of its length which intersects the zone to be served by the proposed railway, and notes and descriptions should be recorded of all reasonable sites. The ideal site consists of banks above the maximum-flood level, with easy access gradients, and containing the river within a relatively narrow gap. The many sites observed in the reconnaissance are generally reduced, by one cause or another, to one, two, or perhaps three. Assuming that two sites remain to be studied in detail, if they be so situated as to affect the whole railway location, or so close to one another that the proposed railway extension is common to both sites, the chief of party should send out two sections of his party, one to each site, in order to determine their relative merits.

This work comes in the category of preliminary lines, with its corresponding degree of accuracy, and with the exception of finding the wetted perimeter and the discharge of the river, may be wholly and advantageously carried out with the tacheometer.

The salient points for comparison are the gradient obtainable into and out of the valley with the earthworks, the class of banks and cuttings, the amount and altitude of bank across the valley with

the maximum-flood level, a geological section if possible, the amount of linear metres and square metres of opening that will be required for the main bridge, together with similar calculations for any additional flood-openings in the valley, and a decision as to whether relatively short or long spans will be the more economical. It must be remembered that it is undesirable to adopt timber trestling across areas that are liable to fire. Investigation must be made as to whether the river has the habit of periodically changing its course and, if so, whether it is advisable to give preference to a site where changes of this kind are less pronounced. A site with hard rocky banks should have preference over one where the banks are liable to erosion.

When floodable areas are crossed, the banks should be stone-pitched on both up- and down-stream sides, or at least planted with bushes on the upper side to protect them from wave-action; as, provided the railway bank is sufficiently strong to resist the static forces of the impounded waters, disintegration is generally caused by the flood water overflowing the rails and scouring the bank on the lower side.

In storm torrent courses the stress on a bank may be relieved or protected by side ditches to convey the storm-water to the nearest bridge or culvert : in such cases aprons are needed at these points.

Stone ballasting of the track will be found a great preventative to destruction of banks over stretches of line which are liable to be submerged.

Meteorology, geology, and mineralogy. — The locating engineer's knowledge of meteorology should be sufficient to enable him to record the characteristics of the climate of the district through which the proposed line will pass. His stay in it will be too short, and his party too mobile, for highly satisfactory results; nevertheless, systematic observations carried out at the base encampment under the second assistant will be of much value for comparison with others made in a known neigbouring climate. The observations should be continued by the constructing engineer, and a system should be permanently organized when once the line is handed over for exploitation. It is, however, the initial meteorological knowlegde required with which this Paper is concerned, and that is more a matter of punctual routine than intricate work.

A rain-gauge should be installed and records taken at a fixed time once every twenty-four hours; automatic gauges, which record the fall during any interval of time, are desirable, to give ideas of the gravity of cloud-bursts and the necessity for the introduction of openings in the bank, side ditches, pitching and aprons.

Complicated devices, however, are apt to become damaged in transport, and the ordinary twenty-four-hour gauge may be adopted, with the addition of notes, to record any phenomenal downpour.

Records of rainfall will also be required for calculating the approximate discharge, yield from the catchment-basin, and floods, and to give an idea of the agricultural and commercial value of the district.

Thermometer readings should be recorded every day at frequent and regular intervals. The automatic recorder has advantages, but the rough handling that occurs when changing encampment is against the employment of delicate instruments; reliance will probably have to be placed, therefore, on ordinary wet and dry thermometers with maximum and minimum readings, from which a curve may be drawn showing the temperature and relative humidity of the atmosphere.

A wind-gauge should be installed to record the direction and force of the wind, not only for general information but also for comparison with the oscillations of the barometer. The latter in-

strument should be an aneroid for mobile purposes, and either an aneroid or an automatic barometer, with temperature reading, for the base encampment. This is the most important meteorological instrument for locating purposes. When an aneroid is used, observations should be recorded every two hours between sunrise and sunset, its index error should be checked, and its altitude should be determined.

A record of the rise and fall of a river, even for a temporary stay, gives a warning in case of floods and serves as a check to any sounding-operations of the field-party. In mountain districts a record of snowfall with information as to its natural drifts is required to determine whether snow-screens will be required for the protection of a proposed railway.

In addition to these actual observations by the location party, inquiries should be made of old inhabitants regarding water-levels, with dates, etc.

A knowledge of geology is a necessary part of the scientific equipment of the locating engineer. In mountainous districts where tunnelling is proposed it is desirable to project through anticlines in preference to synclines, as there will be less likelihood of trouble at the crown of the heading and later less cost in maintenance of the tunnel; further, the longitudinal vertical plane of the crown of the anticline should form the ideal route, especially if the anticline is of short radius, as it forms a natural arch, thus dispensing with the necessity of lining the tunnel. Percolation of water is also largely obviated, for the natural tendency of water percolating between strata is to gravitate towards the synclines.

Faults of all descriptions should be avoided; they not only cause trouble and expense on construction but are also a source of ever-recurring expense of maintenance.

In the case of the tunnel at Kicking Horse Valley, Canadian Pacific Railway, the route under Cathedral Mountain intersected a « shearing fault » at a very acute angle, with quartzite on the one side and limestone on the other, and gave considerable trouble.

The geological formation may vary considerably within a degree of latitude, and in the projection of transcontinental routes in new countries, where mountain ranges have to be crossed, a zone of hard formation may be discovered in close proximity to one that is in a continuous state of disintegration; 60 or even 100 miles deviation in a long pioneer route would be of but little account in hundreds of miles of railway, and need not necessarily interfere with the objective points. The Author knows of an instance of such changes in the mountain formation of the Cordilleras, or Andes, in South American between lat. 37° and 38° S.

Exposed faults on mountain sides overhanging a railway are a source of trouble and danger. The water contained within the voids will freeze in winter and with the succeeding thaw the rock will disintegrate. On some mountain railways this evil is negatived to some extent by building strong rubble walls at the foot of the slope which stop falling detritus.

Mineralogy being the basis on which the selection of natural building materials depends, it is obvious that the locating engineer should not only report on their existence or non-existence, but should know the good from the indifferent. To be able to record this information he must study the composition of the materials. A clerk of works can say whether a material serves its purpose or not when he has tried it, but the engineer should recognize these things without recourse to experiment, which he cannot hope to do unless he has studied the subject.

He should know the various kinds of stones, the more valuable minerals, and their ores, when he sees them, and be able to determine their hardness, cleavage, lustre, streak, colour, crystal form, and specific gravity; also, if necessary, to carry out rough chemical and blowpipe tests. He should be acquainted with the uses of all minerals for commercial purposes.

GEOLOGICAL OUTFIT.

1 geological hand hammer.
1 magnet, bar form.
1 blowpipe, with platinum mouthpiece.
Platinum wire. 0.50 metre.
1 Cl pestle and mortar (small).
1 spirit lamp, with screw cap.
Wick to ditto. 0.30 metre.
Methylated spirit. 0.50 litre.
Refined colza oil. 0.50 litre.
Platinum foil. 0.10 × 0.5 metre.
10 pieces of charcoal, 0.10 × 0.05 × 0.5 metre.
1 forceps, with platinum points.
1 agate mortar and pestle
1 steel pliers.
2 files, small triangular.
12 glass tubes, 1 centimetre diameter.
6 glass rods, 5 millimetres diameter

Re-agents.

Borax powdered crystals.
Microcosmic salt.
Carbonate of soda.
Nitrate of cobalt.
Hydrochloric acid.
Sulphuric acid.
Tin foil.
Copper wire.
Litmus papers. 1 block.
Silver nitrate.
Permanganate of potash.

Prospects. — Traffic prospects cannot be technically included in the training and duties of a locating engineer, though it is incumbent upon him to collect as much information on this subject as possible, in order that he may be able to give his opinion on the prospects of commercial success of the proposed railway.

Information should be recorded of the chemical composition of the top soils and, if salts exist, their kinds; whether the immediate lower stratum is impervious or not; the areas of forest and brushwood, with the names of trees and bushes; the specific gravity, porosity, colour, etc., of the different timbers; the presence and outcrop of stone and other minerals, with mineralogical descriptions of them; also the general fauna and flora of the country. In the populated and cultivated districts which it is proposed to open to railway communication, details should be obtained from the colonists as to yield, quantity, and kind of crops, areas sown, cattle, carrying capacity of the pasture per hectare or acre, rental and values of holdings labourers' wages, road freights, class of roads or tracks, markets, population, local customs, industries, and prospects of developed industries.

The existence of water at any point within the zone of the proposed line should be recorded, the water being classed under three headings :

1° Suitable for locomotive boilers;
2° Potable, but unsuitable for locomotive boilers;
3° Suitable for cattle and agricultural purposes.

It will be very difficult for the locating engineer to determine 1° in unknown country, as there are not likely to be any bores or wells. Upon the water of rivers and streams, however, he will be able to report. He must remember that running water may carry organic matter, may also be charged with an appreciable amount of inorganic matter, which may vary according to the time of year. During flood time rivers may be charged with large quantities of mineral matter,

which may considerably change the colour of the water; care should therefore be taken that the sample is selected when the river or stream is at its normal state. In partly populated zones artesian and open wells will probably exist; the former type is the more reliable for a sample as it doubtless extends below the first water stratum, and there is not so much likelihood of the water being polluted from the exterior. It should also be borne in mind that in a porous soil a well may drain in the shape of an inverted cone as far as 100 metres from its head, and may therefore become contaminated by matter lying within that radius.

Even in the case of artesian wells, cesspits, etc., in the near vicinity may cause pollution by gravitation between two strata or along a geological fault. The water of open wells in congested districts is unsatisfactory for human consumption, though it is the means of supply for the majority of country districts.

The quality of the organic matter is important. If the ratio of nitrogen to carbon is low, the impurity is probably of vegetable origin and comparatively harmless, but if high, it indicates pollution from animal matter and must be regarded with suspicion.

The presence of chlorides is not necessarily harmful, but is an indication that the water may be contaminated by sewage; the class of district will probably enable the locating engineer to satisfy himself on this point. In the neighbourhood of brine deposits, perceptible quantities of sodium chloride, or common salt, may be present and still the water may be potable. The Author has known a locating party to be sustained on hard brackish water for many months without its actually affecting the men, though signs of scurvy showed after six months.

A rough and ready test for potability and for the presence of organic matter is the addition of sufficient permanganate of potash to turn the water pink. If this colour remains unchanged, the water may be accepted as potable, but should it turn to a dirty red or brown the water is unfit for human consumption.

Chlorides give a white precipitate with nitrate of silver (common caustic). A good water should not show more than a slight milkiness.

In mountainous districts streams may contain salts of tin or antimony which give an attractive sparkle to the water, but render it unfit for drinking; their presence can only be detected by a chemical test, and the water cannot be purified without distillation.

Chemistry assists the locating engineer in geology, and especially in water-analysis, and in this way saves the trouble and delay of despatching samples to an analyst. It also helps the mineralogist in the classification of minerals and in reducing with blowpipe and reagents.

It enables him to describe chemically the soils suitable for agricultural purposes, and any salts that he may find deposited on their surfaces.

The value of a camera — preferably one with a specially strong lens — for the purpose of taking technical views to elucidate a report on new country, cannot be overestimated. For that reason one assistant at least should be an expert photographer. Developing and printing accessories should be part of the equipment.

Photographs should be taken of possible bridge-sites, lakes, coast-line, settlements, heavily broken country, forests, classes of cultivation, etc. Views of undulating country are deceptive, and give the impression that the country is easier for railway location than it is in reality. The photographs to accompany a report should be described in print on the face, in order to be self-explanatory.

TABLE I. — **Staff and equipment for a reconnaissance party.**

Staff.

Chief of party

Assistant.

Foreman.

Orderly.

Cook.

Driver.

Stableman.

Technical equipment.

	No.
Aneroids	6
Compasses, prismatic	2
Field glasses	2
Hypsometer	1
Sketching boards	2
Camera, Kodak	1
Films	6
Sketch books	4
Stationery (as required)	...
Royal Geographical Society's handbook	1
Text-books (as desired)	...
Medical case	1
Shot-gun and cartridges	1
Rifle, Winchester, and cartridges	1
Geological cabinet	1

Camp equipment..

		No.
Cart, light, capacity 1 ton		1
Shaft. harness	sets	1
Traces, harness	sets	4
Water-cart		1
— harness	sets	1
Saddlery complete	sets	5
Horses, draft		12
— saddle		10
Tent, 3 metres by 2.5 metres		1
Tarpaulin, large		1
— small		1
Axe, large		1
— small		1
Spanner		1
Fence keys		4
Camp bedsteads		2
Blankets		6
Pillows and slips		2
Table, folding		1
Chairs, folding		2
Lamps, with tubes and wick		1
Hurricane lamps		3
Kerosene	case	1
Saddle soap	tins	3
Whips, cart		2
Hammer		1
Screwdriver		1
Pincers		1
W1 wire	kgr.	5
Nails, assorted	kgr.	5
Rope, spare		...
Mess equipment		...
Cooking utensils		...

TABLE II. — **Staff and technical equipment for preliminary lines.**

Field-party only.

Engineer.	Occupation.	Men.	Equipment.
Chief of party (mounted)		1 orderly (mounted)	Field glasses, aneroid, prismatic compass, termometer, note-book, 2 horses, 2 sets saddlery.
1st assistant	Transit	1 orderly	5-inch tacheometrical transit.
		1 front flagman	12 ranging-poles with bunting, 1 spade.
		1 rear flagman (mounted)	
		1 peg and spademan	Pegs, field book, hand flag, red pencil, tin tacks, 1 horse, 1 set saddlery, 1 axe, 1 machet.
2nd assistant	Employed at base drawing-tent		
3rd assistant	Tacheometer	1 orderly	1 tacheometer.
		6 rodmen	6 tacheometrical staves, 1 steel pocket tape, 1 field-book, 1 hand flag, red pencil, machet.
4th assistant	Right flank topographer (mounted)	1 orderly (mounted)	1 prismatic compass, 1 aneroid, field glasses, 1 thermometer field-book, 2 horses, 2 sets saddlery.
5th assistant	Left flank topographer (mounted)	1 orderly (mounted)	As for right flank, topographer.
Total staff. — Engineers, 6; men, 14.			

TABLE III. — **Staff and technical equipment for final location** (1).

Field-party only.

Engineer.	Occupation.	Men.	Equipment.
Chief of party (mounted)		1 orderly (mounted) (3)	Field-glasses, note-book, 2 horses, 2 sets saddlery.
1st assistant	Transit	1 orderly	5-inch theodolite (transit).
2nd assistant	Employed at base drawing tent		
3rd assistant	Topographer	2 chainmen	12 ranging-poles (with bunting).
		1 front flagman	Box sextant 50 m. chain and 10 arrows.
		1 rear flagman (mounted)	25 m. chain for curve chords.
		2 pegmen	Field-book, H.W. pegs.
		1 spademan	P.P. pegs, zinc disks.
		1 « topogman »	Hand flags, tin tacks, 2 machets, 1 axe, 25 m. tape.
4th assistant	Leveller	1 orderly	1 15-inch level, 2 staves.
		2 rodmen (2)	1 machet, field-book.
5th assistant	Check-leveller	1 orderly, 2 rodmen (2)	As for leveller.
Total staff. — Engineers, 6; men, 16.			

(1) With slight modifications in equipment serves also for trial location. — (2) On occasion this number might be increased to 3 with advantage. — (3) Employed as messenger.

TABLE IV. — **Railway location party.**

Total technical equipment.	No.
5-inch transit theodolites with tacheometrical hairs	2
5-inch tacheometer	1
15-inch levels	4
Aneroids	6
Prismatic compasses	3
Box sextants	2
Plane table complete	1
Field-glasses, prismatic	3
1/2 chronometer watch	1
Kodak camera and 6 rolls films	1
Hypsometer complete	1
Thermometers, protected 140° F.	3
Field-books, topographical	6
— — tacheometrical	3
— — level	16
— — squared paper	2
Axes large	2
Axes large extra if in wooded country	10
Machetes	3
Machetes extra if in wooded country	6
25-metre linen tapes	2
25-metre steel tapes	1
50-metre steel bands	3
100-metre thin bands	1
25-metre steel bands	1
Square-metre bunting, black	3
— — — red	3
— — — white	3
H. W. pegs, 12-per curve. Final location	...
H. W. pegs, 2-per kilometre. —	...
P. P. pegs, say 20 per kilom. —	...
Arrows	20
Staves, levelling	6
Tacheometrical staves	6
Hand flags	2
Ranging-poles	24
Small axes	2
Hammer	1
Fence keys	7
Zinc disks, 10 per kilometre	...
Spades	2

Text books and stationery.	No.
Traverse tables (*Boileau*)	1
Mathematical tables (*Chambers*)	1
Tacheometrical tables (*Jordan*)	1
Curve tables	2
Military Engineering « Miscellaneous »	1
Nautical Almanack	1
Surveying (*Whitelaw*)	1
Engineering Geology (*Reid and Watson*)	1
Preliminary Surveys and Estimates (*Gribble*)	1
Field Engineering (*Shunk*)	2
Whitaker's Almanack	1
Hints to Travellers (*Royal Geographical Society*)	1
Aids in Geology (*G. A. J. Code*)	1
HHHH pencils	12
HH —	24
HB —	24
Red —	6
Blue —	6
Box of coloured crayons	1
— of colours	1
Steel straight edge	1
Large set square 45°	1
— — 60°	1
Small — 45°	2
— — 60°	2
Rolling parallel	1
Box of drawing instruments, complete	1
Nest of saucers	1
Millimetre paper, rolls	2
Tracing paper, rolls	1
Foolscap square paper, blocks	6
— scribbling paper, blocks	12
— report paper, blocks	2
Indiarubber, pieces	6
Geological outfit	1
Drawing pins, small paper-weights, tin tacks	...
Pedometers	2
Anemometer	1
Range-finder	1
Sketching-boards, reconnaissance	2

Note. — Ordinary plant and equipment for encampment will pertain to quartermaster.

TABLE V.

Camping equipment other than technical equipment for railway location party.

(See table IV.)

6 enginers, 1 quartermaster, 2 gangers and 24 men.

	No.
Engineers' tents, 4 metres by 3 metres with poles, ridges, sun awning, floor tarpaulin, pegs and wind guys	3
Tents, 3 metres by 2.5 metres, with ditto	5
Tents (men's) with poles, ridges, pegs and wind guys	6
4-wheeled carts; capacity, 2 tons	4
Sets harness to ditto	4
4 wheeled cart; capacity, 1 1/2 tons	1
Sets harness to ditto	4
4-wheeled water-cart; capacity, 500 litres	4
Sets harness to ditto	4
Light trap	1
Set harness to ditto	1
Draught mules or horses	50
Trotting horses (sulky)	4
Saddle horses	20
Sets of English saddlery	7
— Native saddlery	4
Tarpaulins for cart	5
— for trap	1
Cart whips	9
Trap whips	1
Dandy brushes	12
Curry combs	6
Tins saddle soap	12
Saddle room cloths	7
Camp bedsteads	8
Mattresses to ditto	8
Blankets	24
Linen sheets	16
Portable boring set	1
Drawing table with trestles	1
Mess table with trestles	1
Writing table	1
Portable canvas tables	4
— chairs	8
Stools	6
Axes large	2
Spare handles to ditto	4
Axe, small	1
Spare handles to ditto	2
Sledge hammer	1
Spare handles to ditto	2
Hand hammer	1
Spare handles to ditto	...

	No.
Saw	1
Spades	2
Spanners	12
Primus stove	1
Horse brand	1
Machetes	2
Whetstones	2
Large file	1
Small file	1
Large screwdriver	1
Small screwdriver	1
Sheep-shears	1
Pincers	1
Cold chisel	1
Assortment of carpenter's tools	...
Funnels	2
Punch	1
Set steel numbers	1
Lasso	1
Hand pump for water cart	1
Tubing to ditto	...
Scissors, to cut tin	1
Besoms	2
Milk tins	4
Demijohns	6
Reading lamps and wicks	6
Spare tubes to ditto	24
Hurricane lamps and wicks	6
Buckets	12
Water bottles	8
Medicine chest	1
Sailmakers' needles	3
Canvas baths	2
Wire, kilogrammes	5
Kerosene, cases	2
Colza oil, litre	1
Machine oil, litre	1
Kitchen utensils	...
Mess utensils	...
Foodstuffs	...
Forage	...
Timber scantlings	...
Old tarpaulin	...
Rope	...
Nails, kilogrammes	5
Cart-grease, kilogrammes	10

Note. — This list includes the camping equipment shown in table I.

TABLE VI.

Staff and equipment for a section for marine or deep river soundings in connection with railway location.

Engineer.	Occupation.	Men.	Equipment.
Chief of party.	Directing soundings from boat.	No. 1, Oarsman (1). No. 2, Sounder. No. 3, Recorder. No. 4. Flagman.	Sounding-pole, 5 metres in length, sounding-line, 10 ditto, 1 pair of oars, 50-metre towing-rope, 1 machet, 1 axe, 13 ranging-poles, 1 square metre red bunting, 1 boat-hook, 1 vessel for baling, 1 painter, 10 metres in length, 1 boat, small. with rudder and pair of thole-pins, note-book, spare pegs and tin-tacks, 1 level complete, 2 level-staves.
Assistant . . .	With theodolite.	1 orderly.	Theodolite complete, field-book, ranging-pole with bunting, 1 machet.
Assistant . . .	With theodolite.	1 orderly.	Theodolite complete, field-book, ranging-pole with bunting, 1 machet.

Note. — For shallow soundings the tacheometer is most advantageously employed in conjunction with wading. For staff and equipment see « 3rd assistant, preliminary lines, table II. »

(1) Number may need to be increased, with corresponding equipment, according to size of boat.

Tacheometry. — Graphic diagram (fig. 3) which dispenses with the use of Jordan's tables.

$$\textit{Formula :}\ \text{Altitude} = l \times 100\left(\frac{1}{2}\sin 2a\right).$$

Note. — For readings in field of more than 200 metres, graduations of 0.1 metre are necessary on tacheometrical staff.

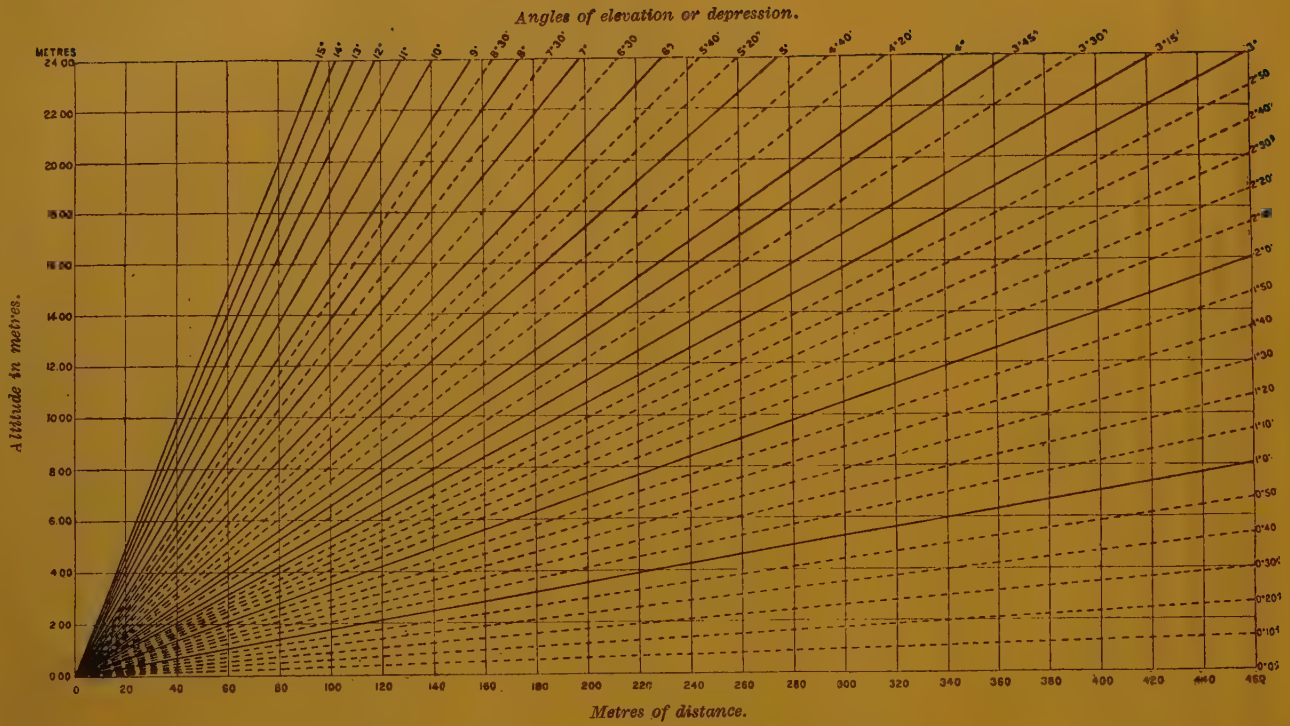
		Vertical arc.	Hairs.
1st example :	Tacheometer field-book reading	= 91° 32′	0.48
(For fall)	Correction	= 90°	2.52
		1° 32′	l = 2.04

Then on diagram find intersection of 1° 32′ with distance 204 metres, and read off altitude = 5.46 metres.

		Vertical arc.	Hairs.
2nd example :	Tacheometer field-book reading.	= 87° 15′	0.3
(For rise)	Correction.	= complement	2.7
		2° 45′	l = 2.4

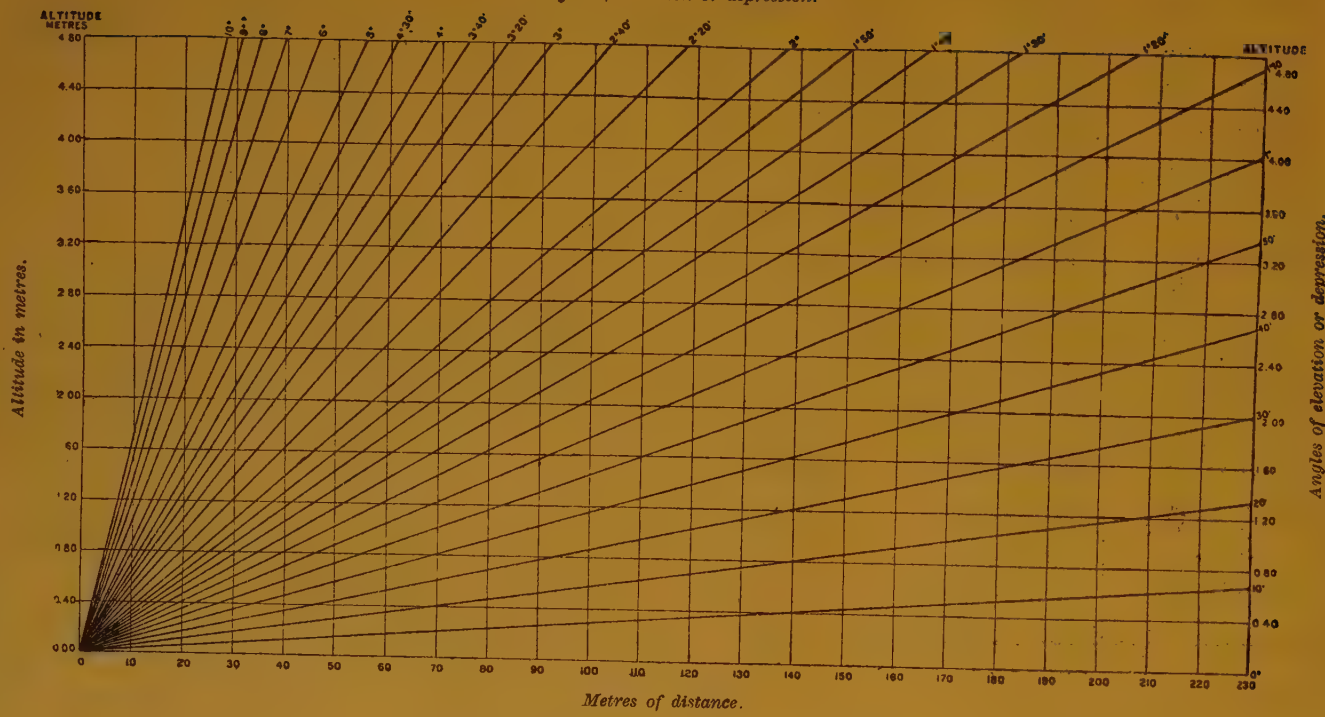
Then on diagram find intersection of 2° 45′ with distance 240 metres, and read off altitude = 11.5 metres.

Figure 4 is used in a similar manner, but gives more accurate results than figure 3 when the angle of elevation or depression is small.



Scales : { Horizontal . . . . . = 1 : 3000
Vertical . . . . . = 1 : 300

Fig. 3. — Graphic table for deducing reduced levels from tacheometric readings.



Scales : { Horizontal . . . . . = 1 : 1500
Vertical . . . . . = 1 : 60

Fig. 4. — Graphic table for deducing reduced levels from tacheometric readings.

TABLE VII. — **Railway location gradients on curves and their compensated equivalents.**

Compensation = 0.04 % per degree of curvature.

Formula : Grade per metre $-\left(\frac{0.6984}{\text{radius}}\right)$ = Compensated grade.

Radius.	Equivalent in degrees of curvature.	Grade (on straight) 1 : 100 = 0.01 per metre.	Grade (on straight) 1 : 125 = 0.008 per metre.	Grade (on straight) 1 : 150 = 0.006 per metre.	Grade (on straight) 1 : 175 = 0.00571 per metre.	1/2 % grade (on straight) 1 : 200 = 0.005 per metre.
Metres						
1 000	1.746	1 : 107^{5} = 0.00930	1 : 137^{0} = 0.00730	1 : 167^{5} = 0.00597	1 : 199^{6} = 0.00501	1 : 232^{5} = 0.00430
950	1.837	1 : 107^{8} = 0.00927	1 : 137^{5} = 0.00727	1 : 168^{6} = 0.00593	1 : 200^{8} = 0.00498	1 : 234^{2} = 0.00427
900	1.940	1 : 108^{4} = 0.00922	1 : 138^{8} = 0.00720	1 : 169^{7} = 0.00589	1 : 202^{8} = 0.00493	1 : 236^{9} = 0.00422
850	2.054	1 : 108^{9} = 0.00918	1 : 139^{2} = 0.00718	1 : 170^{9} = 0.00585	1 : 204^{4} = 0.00489	1 : 239^{2} = 0.00418
800	2.182	1 : 109^{5} = 0.00913	1 : 140^{2} = 0.00713	1 : 172^{7} = 0.00579	1 : 206^{6} = 0.00484	1 : 242^{2} = 0.00413
750	2.328	1 : 110^{2} = 0.00907	1 : 141^{4} = 0.00707	1 : 174^{2} = 0.00574	1 : 209^{2} = 0.00478	1 : 245^{7} = 0.00407
700	2.494	1 : 111^{1} = 0.00900	1 : 142^{8} = 0.00700	1 : 176^{3} = 0.00567	1 : 212^{3} = 0.00471	1 : 250^{0} = 0.00400
650	2.686	1 : 111^{9} = 0.00893	1 : 144^{3} = 0.00693	1 : 178^{8} = 0.00559	1 : 215^{5} = 0.00464	1 : 254^{4} = 0.00393
600	2.910	1 : 113^{1} = 0.00884	1 : 146^{2} = 0.00684	1 : 181^{8} = 0.00550	1 : 219^{8} = 0.00455	1 : 260^{3} = 0.00384
550	3.174	1 : 114^{5} = 0.00873	1 : 148^{5} = 0.00673	1 : 185^{5} = 0.00539	1 : 225^{2} = 0.00444	1 : 268^{1} = 0.00373
500	3.492	1 : 116^{2} = 0.00860	1 : 151^{5} = 0.00660	1 : 189^{7} = 0.00527	1 : 232^{0} = 0.00431	1 : 277^{7} = 0.00360
450	3.880	1 : 118^{3} = 0.00845	1 : 155^{0} = 0.00645	1 : 195^{6} = 0.00511	1 : 240^{4} = 0.00416	1 : 289^{7} = 0.00345
400	4.365	1 : 119^{7} = 0.00835	1 : 160^{0} = 0.00625	1 : 203^{2} = 0.00492	1 : 252^{6} = 0.00396	1 : 307^{7} = 0.00325
350	4.988	1 : 125^{0} = 0.00800	1 : 166^{6} = 0.00600	1 : 214^{1} = 0.00467	1 : 269^{5} = 0.00371	1 : 333^{3} = 0.00300
300	5.820	1 : 130^{4} = 0.00767	1 : 176^{3} = 0.00567	1 : 230^{4} = 0.00434	1 : 295^{9} = 0.00338	1 : 374^{5} = 0.00267
250	6.984	1 : 138^{7} = 0.00721	1 : 191^{9} = 0.00521	1 : 258^{4} = 0.00387	1 : 342^{5} = 0.00292	1 : 452^{5} = 0.00221

MISCELLANEOUS INFORMATION

[313 .385 (.3)]

1. — The world's railways.

We print below a table showing the mileage of the world's railway lines open at the end of the year 1920 and a recapitulatory table exhibiting the growth of the mileage of the railway lines in the various parts of the world between 1917 and the end of 1920.

COUNTRIES.	Mileage open at the end of 1920.
I. — **Europe.**	
Germany. Prussia	21 300
Bavaria	5 420
Saxony	2 000
Wurtemberg	1 397
Baden	1 508
Other States	4 507
Total for Germany.	36 132
Austria	3 931
Czechoslovakia	8 478
Hungary	4 382
Great Britain	24 397
France	33 282
Russia	40 875
Finland	2 564
Poland	9 836
Lithuania	1 939
Latvia	1 770
Esthonia	616
Italy	12 500
Belgium	6 893
Luxemburg	326
Netherlands	2 115
Switzerland	3 321
Spain	9 538
Portugal	2 046
Denmark	2 694
Norway	2 042
Sweden	9 359
Yougoslavia	5 565
Rumania	7 257
Greece	1 859
Bulgaria	1 624
Turkey	621
Malta, Jersey, Isle of Man	68
Total for Europe.	236 030
II. — **America**	
Canada	38 889
United States of America (inclusive of Alaska, 655 m.)	265 033
Newfounland	887
Mexico	15 840
Cent. America (Guatemala, 613 m.; Honduras, 357 m.; Salvador, 204 m., Nicaragua, 200 m.; Costa-Rica, 546 m.; Panama, 298 m.)	2 218
Greater Antilles (Cuba, 2 356 m.; Rep. of Dominica, 400 m.; Haiti, 167 m.; Jamaica, 196 m.; Porto-Rico, 340 m.).	3 459
Lesser Antilles (Martinique, 139 m.; Barbadoes, 109 m.; Trinity, 108 m.)	356
United States of Columbia	882
Venezuela	646
British Guiana	104

COUNTRIES.	Mileage open at the end of 1920.
Dutch Guiana	37
Ecuador	652
Peru	1 728
Bolivia	1 503
Brazil	17 478
Paraguay	291
Uruguay	1 653
Chili	5 301
Argentine Republic	23 156
Total for America.	380 113
III. — Asia.	
Central Russia Territory in Asia and Siberia	10 773
China.	6 838
Japan, inclusive of Corea	9 218
British India	36 324
Ceylon	713
Persia	163
Asia Minor, Syria and Arabia with Cyprus	3 398
Portuguese Indies.	54
Malay States	1 163
Dutch Ind. (Java, Sumatra)	1 882
Siam	1 227
Cochinchina, Camboja, Annam, Tonkin (1 490 m.); Pondicherry (59 m.); Philippine Islands (756 m.)	2 305
Total for Asia.	74 058
IV. — Africa.	
Egypt, inclusive of Soudan	4 363
Algiers and Tunis.	4 220
Marocco	777
Belgian Congo	1 081
South African Union.	11 475
England (British East-Africa, 683 m.; ex-German East-Africa, 891 m.; British Central Africa, 119 m.; Sierra-Leone, 260 m.; Gold Coast, 188 m.; Nigeria, 974 m.; Mauritius, 134 m.; ex-German South West Africa, 1 307 m.).	4 556
France (French Soudan, 1 650 m.; Togo, 203 m.; Cameroun, 193 m.; French Somali Coast (Abyssinia), 473 m.; Equatorial Africa, 1 543 m.; Madagascar, 246 m.; Réunion, 79 m.)	4 387
Italy (Erythrea)	106
Portugal (Angola, 818 m.; Mozambique, 455 m.)	1 273
Total for Africa.	32 238
V. — Australia.	
New Zealand	3 011
Victoria	4 122
New South Wales.	4 436
South Australia	2 221
Queensland	5 212
Tasmania	701
West Australia	3 665
North Territory	200
Hawai (25 m.) with the Isles Maui (7 m.) and Oahu (57 m.)	89
Total for Australia.	23 657

RECAPITULATION.

PARTS OF THE WORLD.	1920	1917
Europe.	236 030	218 631
America	380 113	364 664
Asia	74 058	70 914
Africa	32 238	29 921
Australia	23 657	22 611
Total for the whole world	746 096	706 741

2. — Relative merits of wooden, steel and concrete tanks,

By F. A. ESKRIDGE,

ASSISTANT ENGINEER, CHICAGO & EASTERN ILLINOIS RAILROAD.

(*Railway Age.*)

The first railway water tanks were built of wood and, while other materials are now being used, it is safe to say that the wooden tank will never be discarded entirely. The advantages of the wooden tank are manifold. In the first place, it is the cheapest form of construction. A wooden tank is easily constructed and a carpenter crew assigned to this work soon becomes skilled in its erection. As wood is a poor conductor of heat and cold, it is a desirable material for tanks in cold climates as the water can be kept from freezing more easily. It is not considered practicable to build a wooden tank of larger capacity than 100 000 gallons. The wooden tank carries a certain fire risk and is likely to be damaged or destroyed by fire in the frost-proofing or by the burning of adjacent buildings.

The increasing scarcity of durable timber for the construction of tanks, together with the increased cost, has resulted in a number of railroads constructing creosoted tanks, this type of tank now being standard on at least four railroads. Creosoted tanks are now being built in sizes up to 100 000 gallons capacity. The Illinois Central has 31 creosoted tanks in service and seven more now under construction. The advantage of the creosoted tank over the untreated wooden tank is that any timber that will take treatment can be used, thus making the cheaper timbers available for tank construction. Where the entire structure is creosoted there should be considerable reduction in maintenance as the life of the structure will undoubtedly be much greater and there is no necessity for painting other than the hoops.

The need of larger reservoirs than could be made safely with wooden staves led to the construction of the sheet iron and steel tanks, beginning about 30 years ago. The steel tank can be made of almost any desired capacity and has the advantage that it can be built quickly and is not excessively expensive. It is subject to corrosion and for that reason must be kept well painted both outside and inside. If there should be any neglect in this respect much harm may result. Reports indicate that steel tanks pass through severe freezing winter weather successfully and only the usual precautions for keeping the water from freezing need be taken.

The first reinforced concrete tank was built in this country in 1899, but only 53 had been built in this country and abroad by 1910. Since then many more have been constructed but not as many as the general use of concrete in other lines of construction would lead one to believe. Concrete tanks for railroad purposes are not being given general consideration for various reasons. Very few railroad water stations can be considered permanent because experience has shown that operating conditions are constantly changing, requiring frequent and unexpected changes in yards and tracks. A concrete tank cannot be moved and therefore if the permanency of the location is at all doubtful, it ought not to be built. It is also the most expensive type of tank and as the item of initial cost is often the governing factor in a decision, other types are used instead.

The great problem of the concrete tank is to secure a perfectly water tight reservoir. The first tanks built, as a rule, developed cracks after the tank had been filled with water. While the cracks gradually filled up, especially where the water contained limestone in solution, many of the early tanks had to be coated on the inside with some water-proofing composition. As far as is known, no tanks built recently have been waterproofed by coating the inside.

Much speculation has always existed as to

the effect of severe winter weather on concrete tanks. Many such tanks are in service in northern climates and seem to give no more trouble than tanks of other types. In fact, some claim that the concrete tank stands up better than the wooden tank.

The construction of the concrete tank requires good workmanship. Most difficulties with concrete tanks can be traced almost directly to faults in the construction and it is therefore necessary that the work must be watched carefully.

Conclusions.

A concrete tank will invariably represent a greater first cost than either a steel or wooden tank, yet this first cost is offset to a large extent by a far lower maintenance cost as it is a permanent structure with a life of perhaps 100 years as compared with other tanks having a maximum life not to exceed 50 years. One great disadvantage of the concrete tank is that it cannot be moved after erection.

While the concrete tank is admittedly more expensive than the steel and wooden tank and its greater life and lower maintenance cost are firmly established the relative cost and durability of steel and wooden tanks is still a matter of controversy. An average life of 30 years may expected of tanks constructed of white pine, cypress and redwood while the other untreated timbers used in the construction of tanks will have a life not to exceed 15 years. Properly treated timber will have a life of at least 30 years and probably more. Steel tanks for railway water service have only been constructed during the past 30 years and as some of the first steel tanks constructed are still in service the minimum life of a steel tank properly painted can be based upon this figure with a minimum life of 40 to 50 years, always dependent on proper painting and maintenance. Many of the old style flat bottom steel tanks have failed through the bottom rusting away, and the figures on the life of the steel tank are based upon the modern type of conical bottom steel tank.

A feature of primary importance in the selection and construction of a water tank, and one that cannot be emphasized too strongly, is material and workmanship. As previously stated most of the difficulties experienced with concrete tanks can be traced directly to faulty construction. The manufacture of steel tanks has been developed to such an extent that one is reasonably sure of good material and workmanship as the material furnished by most manufacturers is uniformly up to standard specifications and the construction is usually done by workmen skilled in that particular line of work. The construction of concrete and wooden tanks is sometimes performed by workmen who are no doubt skilled in ordinary concrete work and general carpentry and building but perhaps do not fully understand the requirements of tank construction. Conditions encountered on the average railroad vary to such an extent that it would be unwise to establish any particular type or kind of tank as standard without regard to local conditions.

[628 .172 (.73)]

3. — Cleaning track with a power-driven sweeper.

Fig. 1, p. 73.

(*Railway Age.*)

One of the latest forms of mechanical labor saving equipment for maintenance of way work is a power-driven track sweeper now in use on the Central region of the Pennsylvania Railroad. This unit sweeps up and loads into cars the dirt, chiefly ashes, cinders and coal dust, which fouls the track and ballast with extreme rapidity in the heavy traffic, mountain sections of the road where pusher locomotives are used regularly. An average speed of about four miles an hour is maintained and the track is well cleaned. Tests indicate that the cost is approximately one-half of what it normally would be with hand labor.

The sweeper unit is used chiefly on the pusher grades of the Pennsylvania main line through the Allegheny mountains, *i. e.*, on the westbound tracks from Altoona, Pa., to Gallitzin and on the eastbound tracks from Johnstown, Pa., to Gallitzin. In some instances, sidings and yard sections are also cleaned by this equipment. The dirt accumulates very quickly on this part of the line, there being about 102 miles of track which require cleaning from four to six times annually. This is necessary primarily to keep the signals working properly as well as to keep the track in such condition that a proper inspection of the rail fastenings can be made periodically and that the ballast does not become badly fouled with consequent interference with good drainage.

Fig. 1. — The arrangement of the equipment.

The sweeper consists fundamentally of a rotary steel broom 3 feet in diameter and 7 feet long built up from steel splints measuring 1/32 by 3/16 inch in cross-section. This broom is suspended beneath the frame of an old flat car by special hangers which permit it to be raised or lowered at will. This is accomplished through the use of an air brake cylinder connected with the train air line. The broom turns at about 100 revolutions per minute, and is chain driven from a gasoline engine mounted on the car deck. A steel pan hinged and shaped to fall over the two rails is attached slightly ahead of the rotary broom which sweeps the accumulations up this pan onto a conveyor belt 7 feet wide. This belt operates over two rollers spaced 8 ft. 9 in. center to center and is chain driven. The dirt and ashes are retained on it by 2-inch angles riveted to the belt across the full width of the belt and spaced 1 ft. 8 in. apart.

The debris which has been elevated by this belt is discharged into a hopper which in turn discharges it upon another conveyor belt mounted in an extension boom and running over rollers 24 ft. 2 in. center to center. This permits the final discharge of the accumulations at a convenient distance from one end of a hopper gondola or other type of open top car which is coupled next to the sweeper. The entire arrangement is housed over for protection from the weather and to secure maxi-

mum results in operation. The sweeper unit and car is handled by a locomotive, which can be one of the lightest engines in service as little power is required. The work is generally carried on under traffic and the best results are obtained with the device after a light rain has fallen.

When the unit was constructed an obsolete flat car was procured which was somewhat narrower than the more modern cars. This limited the length of the broom to seven feet. The unit is thus able to sweep out towards the end of the tie for only about 6 to 8 inches from the rail. It does, however, do good work, removing deep accumulations easily and thoroughly. All rail fastenings were uncovered and freed from contact with the dirt. The experience to date after about 50 miles of sweeping has shown that the broom wears but little, there having been only about 1 1/2 inches wear for that amount of sweeping. Heavier splints are being considered, however, not only with the idea of decreasing the wear but to secure a greater depth of cleaning between the ties. Another change contemplated involves the use of shallow buckets in a staggered arrangement on the main conveyor belt instead of the present angles. The broom itself picks up practically everything which may be on the track. Ordinarily about one car of dirt is secured per mile of track swept and this is picked up at a comparatively low cost. A recent test made on a badly fouled section of track where the dirt was mixed with engine sand and well compacted, to determine the costs involved produced the following results :

Cost when using sweeper.

Engine service (including engine and train crew's time, fuel, oil, enginehouse expense and water) 8 hours @ $5.79 . .	$46.32
Sweeper operator—8 hours @ $0.535 . .	4.28
Laborers, 3—8 hours—24 hours @ $0.40 .	9.60
Gasoline—9 gallons @ $0.29	2.61
Motor oil—1 gallon @ $0.72	0.72
Total. . .	$63.53

3828 feet of track cleaned and dirt disposed of, cost per lineal foot $0.0167

Cost for manual labor.

One foreman—9 hours @ $6.28	$ 5.62
14 laborers—9 hours, 126 hours @ $0.40 .	50.40
Total. . .	$56.05

1650 feet of track cleaned and dirt disposed of, cost per lineal foot $0.034

The new sweeper has been developed in the maintenance of way department of the Central region; W. D. Wiggins, chief engineer maintenance of way, and R. Faries, division engineer. The sweeper was designed and constructed by George Ehrenfeld, supervisor of track.

[385 .57 (.42) & 385 .586 (.42)]

4. — Recruiting and training of railway staff.

(*The Railway Gazette.*)

The « grouping » of railways will give rise to many fresh problems of management. If economies are to be realised without loss of efficiency, each of the « groups » will have to pay a great deal of attention to the organisation and training of their staff, with an eye not only to immediate needs, but to the requirements of the future. It is satisfactory to note that our railways are not neglecting the process of building up an establishment that in years to come will produce men competent to take responsible posts under the new *régime*.

Some time ago we published an article describing the educational arrangements of the Great Western Company, and when in York recently one of our representatives took the opportunity of inquiring about the methods followed by the North Eastern. A brief statement of this company's scheme for recruiting and training of staff cannot fail to be of interest at the present time.

The bulk of the entrants into the clerical service of the company join between the ages of 15 and 17. Candidates for employment have to pass a searching test in regard to physical fitness, including eyesight, and have also to undergo a written examination in English composition, arithmetic, geography and other elementary subjects. A fairly high standard is insisted upon, and only about 25 % of the candidates pass this preliminary examination. The successful candidates are appointed on probation for a period of not less than a year before being placed on the permanent staff. After six months' probation a report as to the clerk's suitability for permanent service is made by his immediate superior to the local or district officer. If the report is unsatisfactory it is passed on to the head of the department, who decides whether the probationary period shall be continued or the services of the clerk dispensed with.

An early examination is arranged.

After twelve months' probation a clerk is examined by a relief stationmaster, relief clerk or other competent person nominated by the head of the department, in the work on which he has been engaged. Every clerk is expected to become proficient in shorthand within a reasonable time of his entering the service, and after twelve months' probation he is examined in the subject and is called upon to write at a speed of not less than 50 words per minute and to transcribe his notes accurately. The reports of these examinations, together with the report from the clerk's immediate superior, are sent to the local or district officer, who forwards both reports to the head of the department with his recommendation. If these reports are considered satisfactory, the clerk is continued on probation until the commencement of the following month, when he is placed on the permanent staff. If, on the other hand, the reports are not considered satisfactory, he is either retained on probation for a further period or his services are dispensed with. Any boy who does particularly well at the entrance examination or at these preliminary tests is specially watched, and care is taken to see that he gets a chance to use his abilities to the best advantage.

As soon as he reaches the age of 17 1/2, a junior clerk is eligible to sit for a qualifying test, which is the passport to his advancement to the scale of pay applicable to the fifth-class clerk, when he reaches the age of 18. The qualifying examination is held quarterly at the head or district offices. One of the principal subjects of the examination is « shorthand and typewriting » or « practical telegraphy ». There are also written papers on the duties of a junior clerk and matters of general railway interest, the questions being varied to meet the circumstances in different departments and offices.

Voluntary examinations for ambitious youths.

So far the tests have been compulsory. Next comes a « secondary examination », which is entirely voluntary, though members of the clerical staff get every encouragement from their superior officers to take advantage of the classes which have been instituted by the company for their instruction, and to qualify for certificates. The subjects for the examination are as follow :

a) Regulations for train signalling by block telegraph, and general rules and regulations.

b) 1° Goods station work and accounts, or
2° Passenger station work and accounts, or
3° Locomotive, carriage and wagon accounts and statistics, or
4° Engineering accounts and office work, or
5° Stores department accounts and statistics.

c) Railway operating.

d) Railway economics.

e) Law relating to the conveyance of goods and passengers by railway.

f) Railway and commercial geography of the United Kingdom.

g) A foreign language.

h) An approved examination of similar standard on any other cognate subject.

Classes and lectures on railway and other subjects.

Classes and lectures in subjects *a*) to *f*) are held during the winter months at suitable centres upon the line, such as Newcastle, Darlington, Middlesbrough, York and Hull. Three classes of certificates are issued for a pass in each of the subjects *a*) to *h*), and a final certificate is granted to staff who qualify in five of the subjects *a*) to *h*), which must include *a*) and *b*) and at least two subjects from *c*), *d*), *e*) and *f*). This regulation may seem a little complicated, but it has been drawn up to ensure that full weight is given to railway subjects proper. For successes in subjets *c*), *d*), *e*) and *f*), up to the number necessary to complete the final certificate, money prizes are given on the following basis :

	£	s.	d.
Class I certificate . . .	5	5	0
— II —	2	2	0
— III —	1	1	0

Prizes are not given for successes in subjects *a*) and *b*), but a grant of £5 5 s. (irrespective of the class of passes obtained in the individual subjects) is made to each student who obtains a final certificate within a maximum period of five years.

During the coming winter the company are holding classes in various branches of accountancy and in regulations for train signalling by block telegraph at four centres. They have also arranged with the Universities of Durham and Leeds for the following lectures in advanced railway subjects :

—	Lecturer.	Lecture Centre.
Law relating to the conveyance of goods and passengers by rail . . .	Professor J. D. I. Hughes, M.A., B.C.L., of Leeds University.	Darlington.
Railway operating	Professor H. M. Hallsworth, M.A., of Armstrong College, Newcastle.	Hull.
Railway economics.	Ditto.	Newcastle.
Railway and commercial geography of the United Kingdom	Mr. C. B. Fawcett, B.Litt., M.Sc., of Leeds University.	York.

Each course consists of 20 lectures, and a perusal of the syllabus for the courses shows that the ground is covered in a very thorough manner. The University authorities have worked in close conjunction with the railway company for many years and understand the special needs of their students. It is particularly interesting to see that the institution of these lectures has led to the publication of several textbooks. For instance, the valuable little book on « Statistics of Operation », by the late Mr. C. P. Mossop, was written primarily for the North Eastern Company's students, and Professor Hallsworth also produced for their benefit a handbook on the « Elements of Railway Operating ». The geography lectures, again, led to the production of Mr. L. Rodwell Jones' book, styled « North England : An Economic Geography », which gives a remarkably clear and readable account of the industrial development of the region served by the North Eastern Railway. The company provide certain textbooks either free or at reduced prices, and as a further help to the students

have set up a number of libraries of railway literature in some of their offices and in the railway institutes.

The lectures are invariably well attended — nearly 1 000 students have enrolled for this winter's courses — and the greatest interest is taken by the staff in the results of the secondary examination. A reward is not promised to successful candidates over and above the money prizes already specified, but it is the practice of the company to record the award of certificates and to watch the progress of the men who are doing particularly well.

The traffic apprenticeship system.

As a final step in sorting out the more promising members of the staff, the company have established an annual competitive examination for traffic apprenticeships. Candidates for these appointments must be between the ages of 18 and 22, and the examination embraces the following subjects :

1° Accounts; block working; general rules and regulations;
2° Railway operating;
3° Railway economics;
4° General paper;
5° Essay.

The examination is conducted throughout by the authorities of the Leeds University and Armstrong College, Newcastle, who set and mark all the papers and report the results to the company. Subject to a satisfactory report from the examining bodies as to the standard of the papers, the company appoint as traffic apprentices the five candidates placed first in order of merit in each examination, and may also select any other student who has done particularly well. A traffic apprentice starts, according to age, on a special scale of salary, which gives him at the end of the third year of training about £80 per annum more than an ordinary clerk of the same age. Three examinations have already been held, and 16 traffic apprentices have been appointed and are now in training.

The company also appoint a very limited number of traffic apprentices from outside the service. They are prepared to consider applications from Public School boys or from University men who seem to possess the special qualities and abilities which railway work demands. These appointments from outside are all made on trial, and the company do not retain any apprentice unless he shows exceptional ability.

However he is appointed, a traffic apprentice goes through a strenuous course of training, which lasts three years. During that time he has an opportunity of seeing many branches of railway business, and actually performs the work whenever that can be arranged. Periodical reports are submitted by his superiors to headquarters, and he is expected to pass examinations in practical railway work at various stages of his progress. The training is supervised by a small committee of officers at headquarters, which reports to the heads of the traffic departments, and through them to the general manager.

The total number of apprentices in training at the present time is 30. It is perhaps too early to speak definitely in regard to the success of the scheme, but it seems designed to give the young men of ability amongst the rank and file a chance of coming to the front, and at the same time it introduces a leavening of public school and college-trained men which should be all for the good of the service.

[385. (06.119]

OFFICIAL INFORMATION

ISSUED BY THE

PERMANENT COMMISSION

OF THE

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

STATEMENT

Our General Secretary, Mr. J. Verdeyen, has just been appointed Honorary Corresponding Member of the College of the National Society of Italian Railway Engineers, in recognition of the services which he rendered during the International Railway Congress which was held at Rome in April 1922.

We are delighted with this mark of high esteem which has been shown to our indefatigable General Secretary, and offer him our most hearty congratulations.

The Executive Committee.

[385. (09.2]

OBITUARY

Nicolas Apollonovitch BÉLÉLUBSKY,

Privy Councillor;
Emeritus Professor;
Engineer;
Member of the Technical Committee of the Russian Ministry of Communications;
Reporter and Principal Secretary of the 1st section of the St. Petersburg session (1892);
Delegate at the London session (1895) and the Paris session (1900);
Reporter and Vice-President of the 1st section of the Berne session (1910) of the Railway Congress.

Mr. Nicolas Apollonovitch Bélélubsky, one of the most indefatigable members of our Association, died at Petrograd on 2 August 1922, in consequence of the privations of every kind which have been experienced in Russia during the last few years.

After a brilliant course of study at the Taganrog College and at the Russian Institute of Bridges and Highways, Nicolas Bélélubsky commenced as an ordinary civil engineer. He distinguished himself by his theoretical work and rose rapidly.

He specialised in all questions dealing with the strength of materials, particularly with the construction of metal bridges. It should be mentioned that he was the designer of the remarkable Alexandre bridge over the Volga near Syzrane, and of the Catherine railway bridge at Ekathérinoslaw over the Dniéper.

He was a reporter at the St. Petersburg session in 1892 on question V, section B: « Relation between the bridges and the rolling stock » and at the Berne session in 1910, in collaboration with Mr. Bogouslawsky on question II, section B: « Strengthening the track and the bridges with a view to increasing the weight of locomotives and the speed of trains. »

The reports which he read before the Congress were very remarkable and gave rise to an interesting discussion in which he took a large part.

Mr. Bélélubsky was an honorary Doctor of Engineering, member of the Engineering Committee of the Russian Ministry of Communications, Emeritus Professor, Director of the Mechanical Laboratory and honorary member of the Imperial Institute of Transport Engineers, President of the International Association for testing material, honorary member of the French Society of Civil Engineers, and President of many other scientific societies.

He was a Commander of the Legion of Honour, Grand Officer and Officer of a number of other foreign orders.

We offer to the family of our lamented collaborator our most sincere sympathy.

The Executive Committee.